How the brain works

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ABSTRACT

This paper analyses the associative capabilities of the brain and takes the consequences of that capability.

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Preprocessing

A study on how the environment is observed and interpreted should start with an investigation of how the sense-organs and the brain cooperate. Between the sense-organs and the brain exists a series of pre-processors that encode and pre-interpret the incoming signals. This process also performs some noise filtering, such that later stages of the processing are not bothered by misinformation. For that reason the pre-processors act as decision centres where the signal transfer is blocked when the signal to noise ratio stays underneath a given level, e.g. 2.3 (Crozier's law. The level may differ in different persons.). In this way the visual trajectories run via a cross-over to the cortex. The cross-over encodes and adds depth information. After a series of additional pre-processing steps the signal arrives in the fourth cortex layer. Here about four square millimetres is devoted to the direct environment of each receptor of the fovea. In this area a complete geometric encoding of the local geometry and dynamics of the perceived picture is presented. This includes whether the detected detail is a line or an edge or another form, in which direction it is positioned and whether the detail moves. (See the papers of Hubel and Wiesel on the visual trajectory and the visual cortex for more detailed information).

Processing

Thus, the brain does not work with a pictorial copy of the picture that is received on the fovea. In further steps the encoded map is interpreted. That part of the brain tries to associate the details of the map with remembered and recognized items. When dynamics is considered then it must also be considered that the eyes are continuously scanning the input scene.

Image intensification

I studied visual perception because I needed this to specify useful measuring standards for night vision and X-ray imaging equipment (~1975). Many of the known visual illusions are due to the pre-processing in the visual trajectory. The viewing chain includes lenses, image intensifier tubes and either a camera or the human visual system. This last component includes the eye ball. The object is noisy and can be considered as a Poisson process. With respect to the noise the optical components act as binomial processes. Their point spread functions act as integration area. Image intensification is usually a Poisson process, but channel plates are characterized by an

exponential distribution rather than by a Poisson distribution. Chains that include Poisson processes and binomial processes can be considered as one generalized Poisson process. Thus, imaging chains that include channel plates are more difficult to characterise.

Imaging quality characteristics

When the imaging chain can be characterized by a Poisson process, then its quantum detection efficiency can be characterized by the Detective Quantum efficiency (DQE). Its optical imaging quality can be characterized by the Optical Transfer Function (OTF). With inhomogeneous light imaging it is sufficient to use the modulus, the Modulation Transfer Function (MTF). The MTF of the chain is the product of the MTF's of the components of the imaging chain.

Vision of noisy images

The intensification of image intensifiers is such that at low radiation levels the output image is formed by large numbers of separate light dots that together give the impression of a snowy picture. The visual trajectory contains a sequence of pre-processors that each performs a part of the encoding of the object. At its input the visual cortex gets an encoded image rather than an optical image of the perceived scene. This encoded image is further encoded and interpreted in channels higher in the brain. This is done by associating the elements of the encoded image that is entering the visual cortex. The folded visual cortex offers about four square millimetres for the encoding of the environment of each separate receptor in the fovea. The pre-processors act as decision centres. When the offered signal to noise ratio is too low then nothing is passed. This is a general principle in the encoding process and also governs the association of encoded data in other parts of the brain.

The research resulted in a significant contribution of our laboratory to the world standards for the measurement of the OTF and the DQE.

Information association

The associative nature of the process is common for al kinds of objects and parts of objects. That includes objects that did not enter

through one of the sense-organs. For example a house is not stored in the brain as a complete concept. It is stored as a series of details that can be associated to the concept. If a sufficient number of these details are detected then a decision centre in the brain decides that the whole concept is present. In this way not only a particular house can be recognized, the process can recognize a series of objects that resemble the original house. It classifies houses. By adding details that can be associated with it, the concept of a house can be widened. The resulting information, i.e. the information that passed the decision centre, is used for further reasoning. Together with other details the same details can also be used to detect other concepts by a different association. When the association act still produces too much noise, then the information is not produced and further reasoning is neither disturbed nor triggered by this fact. High enough in the hierarchy individuals can be discerned. The brain is not static. The network of communication paths and decision centres is dynamically adapted to the changing needs.

Noise filter

The decision level for the signal to noise ratio may vary from person to person. If the level becomes too low the person may start hallucinating. Further, the level may be influenced by body owned messenger stuff, drugs, poisons and medicines.

Reasoning

The brain is capable to perform complex reasoning. However it must be trained to perform the reasoning in a logical way. For example, it must learn that the start from a false presumption can cause the deduction of any conclusion, just or false. When a path of reasoning is helpful, then it is stored in a similar way as an observation. Not the reasoning itself is stored, but the details that are part of the reasoning path. Also here association of the details and a suitable noise threshold plays its role. The reasoning can be identified as a theory and its concept can be widened. The brain can also generate new details that together with existing details can act as a reasonable theory. Even noise can generate such signals. These details can be perceived as a dream or as a newly invented theory. It depends whether the theory is

accepted as realistic. That means that the brain must be capable of testing the realism of a theory. This testing can be improved by training. The brain can forget stored details and stored concepts. This holds for objects as well as theories. Valuable concepts are regularly refreshed and become better remembered.

Other species

Hubel and Wiesel did their experiments on several kinds of vertebrates, such as goldfishes, cats and humans. Their main target was visual perception. Where the handling of the signals of sense organs in the brains is quite similar for all vertebrates, the handling of paths of reasoning by humans is superior in comparison to other vertebrates.

Humans

Humans have an advantage over other vertebrates. Apart from direct observation the theories and the concepts of things can also be retrieved by communication with other parties. This occurs by education, discussion, reading books, papers or journals, seeing films or videos or surfing the internet. These media can also act as a reference medium that extends the storage capacity of the brain.

Science

Mathematics is a particularly helpful tool that extends the capability of the brain to perform reasoning in a logical and precise way. Physics extends this capability further with focus on observables. Philosophy adds self reflection and focuses on the why and how of existence. Every branch of science adds to the capabilities of the individuals and to the effectiveness of the community.

Physical reality

Our brain has a limited storage capability. We cannot comprehend things that have an enormous complexity. However we can detect regularities. Our brain is optimized to detect regularities. The laws of physics appear regularly in our observations or can be deduced from regularly returning observations. More complex laws are derived

using tools and in combination with other people. Nature is not only controlled by laws. It is also controlled by boundary conditions. These boundary conditions may be caused by the influence of items that lay beyond the reach of our direct observations. The number and complexity of boundary conditions far outgrows the number of recognized laws of nature. The laws of nature play a role in our theories. However, the boundary conditions play a much smaller role. This is because the laws of nature that we detect treat a simplified version of the environment. In this abstraction the boundary conditions play no realistic role. This is another reason why our theories differ from physical reality.

Theories

These deliberations learn that theories are a product of our mind. They can be used as a looking glass that helps in the observation and interpretation of physical reality. However, it is false to interpret the theories as or as part of physical reality. When a theory fits, then it is congruent, to some extent, with physical reality. That does not say that we as human beings and the environment from which we take our observations are not part of reality. It says that what our brain produces is another thing than physical reality.

Inventions of the human mind

Infinity is typically an invention by the human mind. There exist strong indications that nature does not support infinity. In the same sense unlimited precision real numbers are prohibited in the physical universe by the holographic principle and the Bekenstein bound. However, we can embed the results of our observations in a model that includes infinities and unlimited precision. For example classical mechanics and field theories use these concepts. Quantum mechanics shows us that as soon as we introduce unlimited precision we are immediately confronted with Heisenbergs uncertainty principle. We need infinity and unlimited precision in order to resolve the paradoxes that otherwise creep into our theories. We use theories that are in direct conflict with each other. One forbids infinity, the other theory uses and requires it. This says at least one thing; none of the theories describes physical reality correctly. Thus none of the theories can

replace the concept of physical reality. Still it appears useful to use both theories side by side. It means that great care must be taken with the interpretation of the theories.

History

Mathematical theories and physical theories tend to build upon the results of other exact theories. After some generations a very complex building is obtained. After a while it becomes humanly impossible to check whether the building elements are correct and whether the binding is done correctly. So, complex exact theories should be questioned.

Dreams

In this sense, only when we study our own dreams, fantasies or theories, then we observe these items and the dreams; fantasies and theories become part of "physical reality". If the theory is congruent with a part of physical reality, it will become useful as a view on physical reality.