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WERNER E. REICHARDT (1924-1992): IN MEMORIAM

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Professor Werner E. Reichardt died on September 18, 1992 in Tuebingen.
He collapsed and lost consciousness at the end of a symposium that was organized in his honor by his coworkers and friends on the occasion of his retirement. He left his wife, Barbara Reichardt, two adult children, Andrea and Cornelius, and his grandson Johannes.
Werner Reichardt was the founder of the Max-Planck-Institut für biologische Kybernetik in Tuebingen, and one of its directors since 1968.
He was in many ways a fascinating person and an example for many young colleagues who accompanied him on parts of his way. In matters of sciences he fought for thoroughness and top quality. He was always ready to accept a good argument even if he had to change his opinion. In dealing with persons he was friendly and absolutely loyal. With friends he was warmhearted and unfailingly sincere.

1.Youth and early experiences:

Reichardt was born 1924 in Berlin. Despite the depressing economical and political atmosphere of this time, he enjoyed a protected childhood. He became interested in physics already during school time, volunteering in the private laboratory of H.E. Hollmann, a pioneer of ultra shortwave communication. Right after his high school graduation in 1941 Reichardt was called to the air force and served in a technical unit developing long distance radio communication for weather forecasts.
His parents were killed in January 1943 during the first bomb attack on Berlin.
This allowed Reichardt to join a resistance group trying to establish a radio contact with the Western Allies. That was found out by the Gestapo at the end of 1944. Reichardt was arrested and expected his execution. In the last days of the Nazi regime he managed a narrow escape during a rebellion of prisoners and could hide himself in Berlin until the end of the war.
These early and horrifying experiences made Werner Reichardt an earnest person who was always aware of the presence of death and the preciousness of time where one is free and able to do something sensible.

2. The way into neuroscience:

After the war, Reichardt studied physics at the Technical University in Berlin, received his Diplom (master's degree) in 1950 and finished his studies with a doctoral thesis in solid state physics of semiconductors in 1952.
He got a postdoctoral position at the Fritz-Haber-Institute of the Max-Planck-Society in Berlin, doing research on semiconductor physics.
Reichardt's way into science and especially into neurobiology was all but a routine carreer; it was repeatedly influenced by encounters with eminent scientists.

In 1950 he met again Bernhard Hassenstein, a former colleague from the air force radio unit.
At that time Hassenstein had finished his doctoral thesis in the laboratory of Erich von Holst in Wilhelmshaven on the optomotor turning behavior of the beetle *Chlorophanus*. Reichardt realized that these experiments could be strictly formalized. He applied, to the beetle's visual behavior, the methods of systems analysis very much like an electrical engineer studying an unknown component of telecommunication equipment. The concept was, to infer from the experimental facts, the minimal logical structure that would produce the observed behavior in response to the applied stimuli. The model should provide non-trivial quantitative predictions about the outcome of conceivable experiments that had not been done before.

In 1950 this was quite an unusual way of thinking about a mental process like visual motion perception. The first papers on this topic attracted the attention of Max Delbrueck who invited W. Reichardt in 1954 to the California Institute of Technology in Pasadena to study the light-growth-reaction of the sporangiophore of the fungus *Phycomyces*. The year in the USA brought him many personal relations and friendships lasting his whole life. He decided to move into biology.

3. Establishment of the new field

Back to Germany, Reichardt became in 1955 Research Assistant in the department of K.F. Bonhoeffer at the MPI für physikalische Chemie in Goettingen. Together with B. Hassenstein and D. Varjú he worked out the properties of the insect motion detector. Sophisticated visual stimuli were presented to the beetle *Chlorophanus*, held by its back in a fixed position while climbing on the grass-like ribs of y-maze globe. The frequency of left/right choices revealed its intended turns.
This way it could be shown that its motion detector required at least two input sensors looking into slightly different areas of the visual field. These sensors are excited in sequence by pattern edges moving by. If one input signal is delayed appropriately the two signals become synchronous for the "preferred direction" of pattern motion but strongly asynchronous in the opposite direction. Multiplication of the two signals and time-averaging of the result yields a direction-specific motion signal irrespective of the polarity of the change of brightness achieved by a moving object. This process corresponds formally to an autocorrelation of the input signal. Hence the name "correlation-type motion detector".
Since the beetle responds also to motion in the opposite direction, two antisymmetric detector subunits must be combined and their outputs subtracted. This step eliminates unspecific signal components of the subunits and thus increases directional selectivity of the motion detector.
In 1958, after Bonhoeffer had died, a Research Group for Cybernetics was established at the MPI for Biology in Tuebingen. It was led by W. Reichardt, B. Hassenstein and H. Wenking who supplied the group with specially designed sophisticated electronic equipment. Young colleagues joined the group and worked an different problems of sensory transduction and visual perception in as diverse organisms as *Phycomyces, Limulus, Drosophila* and the housefly *Musca*.

In 1960, Hassenstein left the Cybernetics group to become full professor and head of the Zoology department at the University of Freiburg.
Reichardt received offers from the California Institute of Technology in Pasadena, from the Massachusetts Institute of Technology in Cambridge, from the Bell Laboratories in Murray Hills and from the Max-Planck-Society which he accepted.

Reichardt convinced the Max-Planck-Society that his project needed more space. A separate building for his Department at the Max-Planck-Institute for Biology was opened in 1965. On this occasion he explained his view on how to study central nervous systems on different levels of organization, naming the kinds of phenomena to be observed and the means of analysis:

Table 1

LEVEL	PHENOMENA	DESCRIPTION
1) whole animal	behavior	system performance
2) nerve nets	signal flow	algorithms
3) single cell	membrane potential	current flow
4) membrane patch	charge transfer	molecular action

Reichardt believed that the study of nervous systems on each of these levels presents specific problems that require appropriate concepts and methods. He was convinced that results gained on lower levels are not adequate to explain specific performance on higher levels. But he was confident that insights gained on higher levels help to ask the right questions and to do experiments in the right way on lower levels. And above all he was sure that it would be necessary to study nervous systems on all levels simultaneously and preferably in the same organism. Consequently he planned and succeeded to expand the working base of his department.

In 1968, his department was transformed into the Max-Planck-Institute for biological Cybernetics. The existing building was enlarged and three co-directors were appointed for different though closely associated fields: Valentino Braitenberg from the Cybernetics Institute in Naples was intended to unravel the neuroanatomy of the fly's visual nervous system. Kuno Kirschfeld from Tuebingen and his coworkers studied physiological optics, visual pigments and phototransduction. Karl G. Goetz, also from Tuebingen used neurological mutants of *Drosophila* to reveal how genetic instructions are translated into functional structures of the fly's central nervous system.

Until now many young colleagues have joined the four groups, have contributed to the solutions of many questions in insect vision and have spread over German and foreign universities to pursue Reichardt's concepts in their own responsibility and personal handwriting.

4.New research projects

The new collegium of directors relieved W. Reichardt from administrative duties. He embarked an new research adventures: The flight torque of a fly, flying stationarily in the center of an illuminated arena, can be measured and can be used to control the speed of the optical panorama in a negative feedback configuration. This allows the fly to chose where to fly and enables the investigator to interfere in defined ways with the structure of the panorama and the coupling between the fly's actions and their consequences.

From the results of these experiments, W. Reichardt and T. Poggio developed a phenomenological theory of object fixation and tracking by the fly. The simulation of the fly's control system predicted, with surprising quantitative and qualitative accuracy, the observed free flight trajectory of a fly chasing its quarry.

In 1977 Reichardt discovered that flies use motion discontinuities in the visual surround to distinguish objects from the background. Flies turn towards a single, randomly textured stripe in front of an equally textured background, but only as long as it moves relative to the ground.

Reichardt and Poggio developed a model of nonlinear lateral inhibition between motion detectors to account for these findings. This class of models is characterized by a higher nonlinear order than the elementary motion detector.

At this time, K. Hausen and myself had developed the techniques for intracellular recording and staining of motion-sensitive wide-field neurons. Some years later M. Egelhaaf discovered figure-detection neurons that are inhibited by wide-field motion of the visual background. Thus we could study the actual neural circuitry of self-motion perception and figure/ground-discrimination. The close interplay between behavioral analysis, theory and neurophysiology guided this work very efficiently and led to a profound understanding of these perceptual processes, very much as Reichardt had suggested way back in 1965.

4. Duties and Honors:

Besides his engagement in the laboratory and the Institute, W. Reichardt served as scientific advisor in committees all over the world.

In 1984 he was elected into the Senate of the Max-Planck-Gesellschaft, the top ruling board of this society.

In 1961 Reichardt had founded the "Journal of Biological Cybernetics" for which he served as Editor-in-Chief until his untimely death.

Since 1970 he was Honorary Professor at the University of Tuebingen which helped to attract qualified students of Neurosciences to Tuebingen.

Over the years, Reichardt was honored by election into several Academies: 1970, Akademie der Wissenschaften und Literatur in Mainz; 1971, Deutsche Akademie der Naturforscher Leopoldina in Halle; 1972, American Academy of Arts and Sciences in Cambridge MA; 1977, Koninklijke Nederlandse Akademie van Wetenschaapen in Amsterdam; 1988, National Academy of Sciences in Washington; and 1989, American Philosophical Society in Philadelphia and Academia Europea in Cambridge, England. In 1989, he received the degree of an Honorary Doctor of Engineering from the Technische Hochschule Aachen.

In 1980 W. Reichardt was elected as a member of the prestigious Order Pour le Mérite. That was originally founded in 1740 by Friedrich dem Grossen of Prussia; the Class of Science and Arts was founded in 1842 by Friedrich Wilhelm IV of Prussia on advice of A. von Humboldt.
In 1985 B. Julesz and W. Reichardt were awarded with the H.P. Heineken-Prize of the Royal Dutch Academy.

W. Reichardt enjoyed these honors. He felt that the scientific community had acknowledged his approach to neuroscience which was not at all guaranteed in the beginning. He was proud of the new insights produced by his and his collaborators' work and he was confident that this kind of computational neuroscience would stand the challenges of future demands.

Werner Reichardt's sudden and much too early death has deprived the scientific community of an eminent pioneer in this new field of research.
For many of us he was not only the distinguished senior of our Institute but also a warm-hearted friend over many years whose opinion and advice were seeked and respected. We will not forget him.