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Change of Concepts of Behaviour over the Last 60 Years at Humboldt University Berlin

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With 18 Figures and 2 Boxes

Abstract

On September 1st, 1948, the institute of ethology or behavioural sciences was founded as *Forschungsstätte für Tierpsychologie* at Humboldt University Berlin. One of the first research subjects was Susi, the only chimpanzee surviving the war at the Zoo Berlin which resulted in my first book with an ethological approach *Grundzüge der Schimpansen-Psychologie* (*Outlines of Chimpanzee Psychology*). Basic concepts about communication and the development of behaviour emerged from the synthesis of evolutionary theory, systems theory, biocybernetics, and theory of self-organization, but also the development of computer technology had a decisive influence. Thus, a clear distinction from former animal psychology led to classical ethological themes defining "the concept of behaviour as organismic interaction with the environment on the basis of an exchange of information ensuring individual, ecological and inclusive fitness".

Some selected aspects will be addressed: Acoustic biocommunication was not seen as an isolated incidence of sound utterances, but as an interaction between sender and receiver, defined as *affine,* i.e. attractive, distance reducing and *diffugous,* i.e. aversive, distance enhancing sounds, whereas ambivalent *intermediary* signals stabilize the distance. It was part of the research on the behaviour of foxes, that led to a substantial increase of the *Tierstimmenarchiv* (Archive of Animal Sounds) and to the formation of *bioacoustics*. The *Three-Vector-Model of Behaviour* was developed as a framework for studying behaviour. Other specific concepts of behaviour as for example chronobiology and the *Theory of Strata* with four 'strata (layers)' emerged: evolutionary, biogenetic, tradigenetic and ratiogenetic potential. In the 1980's the research concept *Humans as Bio-psycho-social Units* incorporating various aspects into the basis of human behaviour was developed in close cooperation with endocrinologists, developmental psychologists and philosophers.

Zusammenfassung

Am 1. September 1948 konnte die *Forschungsstätte für Tierpsychologie* am Zoologischen Institut der Humboldt-Universität zu Berlin begründet werden. Dieses Vorhaben war bereits auf den Weg gebracht, da zuvor mein Kontakt mit der den Krieg überlebenden Schimpansin Susi im Zoo Berlin, verbunden mit Verhaltensbeobachtungen und einigen Versuchen, dazu führte, dass dann 1949 ein Buch unter dem Titel *Grundzüge der Schimpansen-Psychologie* erschien. Grundfragen der Kommunikation und der Entwicklung des Verhaltens ergaben sich aus der Synthese von Evolutionstheorie, Systemtheorie, Biokybernetik und der Theorie von der Selbstorganisation, aber auch die Entwicklung der Computertechnologie hatte einen entscheidenden Einfluss. Somit führte eine klare Unterscheidung von der früheren Tierpsychologie zu klassischen ethologischen Themen und der Definition: „Verhalten ist organismische Interaktion mit der Umwelt auf der Grundlage eines Informationswechsels im Dienst der individuellen, ökologischen und inklusiven Fitness."

Einige ausgewählte Aspekte werden erörtert: Der wissenschaftliche Ansatz ging grundsätzlich davon aus, dass die akustische Biokommunikation nicht eine isolierte Erscheinung von Lautäußerungen darstellt, sondern eine Interaktion zwischen Sender und Empfänger, die, wenn als *affin* definiert, d. h. attraktiv, zu einer Distanzverringerung führt, als *diffug,* d. h. bei aversiven Lauten zu einer Distanzvergrößerung, wogegen ambivalente Signale, *intermediäre*, für die Aufrechterhaltung innerhalb eines bestimmten Abstandes sorgen. Unsere Forschung über das Verhalten des Fuchses sorgte für eine beträchtliche Erweiterung des *Tierstimmenarchivs* und die Einrichtung der Bioakustik. Das *Drei-Vektoren-Modell des Verhaltens* wurde als Rahmenkonzept zum Studium des Verhaltens entwickelt. Andere spezielle Verhaltenskonzepte wie z. B. die Chronobiologie und die Schichtlehre entstanden: evolutionsgenetisches, biogenetisches, tradigenetisches und ratiogenetisches Potenzial. In den 1980er Jahren wurde in enger Kooperation mit Endokrinologen, Entwicklungspsychologen und Philosophen das Forschungskonzept *Biopsychosoziale Einheit Mensch* entwickelt, das verschiedene Aspekte als Grundlage menschlichen Verhaltens integrierte.

In the year 2009 Charles Darwin (1809–1882) became the focus of life sciences since it was he who had created a new view of the world. He also inspired George Romanes (1848–1894) to describe behaviour in his sense. His representation is determined by the following questions: "The Criterion of Mind; The Structure And Function of Nerve-Tissue; The Physical Basis of Mind; The Root-Principles of Mind; Conciousness; Sensation; Pleasures And Pains, Memory, And Association of Ideas; Perception; Imagination; Instinct; Origin And Development of Instincts", all to be pursued in detail (Romanes 1883). Regarding the central topic of 'instinct' Darwin (1883) also provided his contribution, orientated as always on examples.

Against this background my scientific life has been developed and maintained. Already as a school boy I kept arthropods, particularly myriapods and coleoptera in adequate conditions and spent many hours in nature to watch animals. Animal sounds also attracted my special attention. I reflected on evolution, kinship of animal and wo/man as well as the nature of the sexes. Hence, it became obvious that I should follow certain crucial points during my studies just like during school-time. After my Ph.D. thesis on a beetle (*Carabus ullrichi*) and the evolution of sub-species (1941, see Tembrock 1942, 1944/2004), I turned to behaviour in 1948. At that time there were no concepts within the university curricula in Germany and Konrad Lorenz (1903–1989) who was a professor in Königsberg returned from war imprisonment only in 1948. Thus, my proposal for the establishment of a respective research group at the Berlin University (1946–1949, then Humboldt University Berlin) was substantiated as sub-department of animal behaviour (*Forschungsstätte für Tierpsychologie*) with the support of the German Academy of Sciences. Two scientists and two technical assistants were envisaged. This was realized on September 1st, 1948 (see also Box 1). The following crucial aims were formulated: 1. analysis of principles of animal behaviour, 2. analysis of endogenous psychological processes, 3. investigation of innate behaviour patterns, 4. investigation of learned behaviour (particularly associations, learning capacity, memory, insight behaviour and abstraction), 5. analysis of instinct actions and their releasors (releasing mechanisms) (see also Box 2).

The concept is clearly autonomous which was also a reaction to the ideologically influenced concepts prevailing in Germany until 1945. At that time Konrad Lorenz' essay on *Innate forms of possible experience* was discussed critically (Lorenz 1943). Over 12 years of dominating ideology had left its mark and only slowly – beginning in 1949 – new concepts and questions emerged. Our way started 1948 after having made observations of and some experiments with the only surviving female chimpanzee of the

Box 1
Letter to Konrad Lorenz, 1949

In order to avoid portraying those times only in retrospect it may be permitted to cite a letter to Konrad Lorenz dated August 25th, 1949 in extracts:

"Our venture roots in my chimpanzee studies. They show me that the research needs to be broadened to achieve appreciable successes. Hence, I contacted the relevant authorities, especially the university [...] and the academy of sciences met my plans with much understanding thus enabling me in the autumn of last year to bring the 'Research Station for Animal Psychology' ('*Forschungsstätte für Tierpsychologie*') into being. I believe in filling a current gap, and particularly hope to interest the young generation yet again for animal psychology to a greater extent and to offer appropriate research opportunities. Thus, already two Ph.D. students are operating here, one on squirrels and the other on mice (behavioural analysis, displacement activities and others). Furthermore, I could gain two assistants: Ms. Dr. Kettner who graduated on colour vision of fishes with Prof. Herter and Mr. Dr. Ohm who specializes on cichlids. Next, I considered it crucial to establish card files of references incorporating all relevant papers which has already progressed quite a bit. A file of photographs is in the making (an indispensable tool of animal psychology), accordingly, a film archive is planned. Understandably, the library increases slowest as unfortunately, the flow from outward sources is indeed very sparse. At the very beginning, coincidence led a fox to us so that we found our first research animal without knowing that Dr. Seitz had already collected much more extensive material. Happily, our projects seem to complement each other well so that we – lacking appropriate outdoor facilities – can carry out behavioural studies only marginally (and under very artificial keeping conditions in rooms)... Thus, we work primarily experimentally with issues of gestalt psychology and association problems have particular priority inspired by a paper of W. Köhler (which I cite in my paper enclosed). Furthermore, we examined colour vision of foxes which appears to be close to that of dogs. Six foxes live with us at the moment. Some golden hamsters, one Siberian hobby, a Little owl and a magpie as well as squirrels and diverse cichlids complement our little zoo. I don't know whether you know our zoological institute here in Berlin, where we have four rooms at our disposal; naturally, one can't accommodate much here. However, with the vegetable gardening decreasing I begin to reserve our garden hoping to be able to install there some outdoor enclosures. Moreover, I consider working in the zoo with complaisance of Ms. Dr. Heinroth thus expanding the base step by step, since only comparative and once again comparative studies can further our cause. In seminars and colloquia we try to clarify terms and to stimulate the young generation. Thus, I hope to succeed with our modest means to contribute a bit to our science which needs above all good observers and experimenters who also understand really getting into contact and building up a relationship with the animal."

Zoo Berlin (Fig. 1) leading to a book with the title *Outlines of Chimpanzee Psychology* (Tembrock 1949a). This presentation shows elements characterizing the start of behavioural biology in connection with the concept of the sub-department of animal behaviour founded in 1948 at Humboldt University having been pursued for now over 60 years. One may detect an 'evolution' leading now to global concepts which maintain a holosphere as a synthesis of biosphere and noosphere linked with viable and sustainable behaviour.

Box 2

Schedule of work documented for the first years of the Sub-Department of Animal Psychology at the Zoological Institute of the Humboldt University Berlin (founded September 1st, 1948; funded by the German Academy of Sciences).

Schedule of Work 1948/49

1. Basic research
   – Field studies
   – Studies under captive conditions
   – Experimental research: field, zoological garden, laboratory

   Topics and questions:
   – Physiological basis of animal behaviour
   – Analysis of endogenous (psychological) processes
   – Ontogeny of innate behaviour
   – Acquired types of behaviour
   – Analysis of innate behaviour, fixed action patterns, and releasing mechanisms

2. Establishment of methods for the application of results of basic research for keeping and breeding of animals

Schedule of Work 1950

1. Experimental research of red foxes
2. Observation on releasing mechanisms of various species
3. Investigation on reproductive behaviour in cichlids
4. Installation of a central literature index
5. Establishment of a film and slide collection
6. Installation of a subject-catalogue (for a dictionary)

Schedule of Work for 1951

1. Installation of a literature and figure catalogue
2. Comparative-psychological studies on canids
3. Studies on reproductive behaviour in cichlids
4. Continuation of the studies on the behaviour of chimpanzee "Susi"
5. 2 PhD students work on guinea pigs, rats, and mice
6. Installation of the working library

Public work in the media (magazines, radio, including West-Berlin) and public lectures.

Our research station began critically debating 'animal psychology' against the background of *Chimpanzee Psychology* applying the argument that insights can only be won by including the evolutionary process as already requested by the concept of research of 1948 (see Box 2). Thus, I can assume that this started the long way to be talked about here. The next step is marked again by a book that appeared in 1956 allowing for portraying these unu-

Fig. 1 First visit of the author to chimpanzee Susi on May 13, 1947, at the Berlin Zoo (from Tembrock 1949a).

sual 60 years very precisely and not glossed over (Tembrock 1956).[1] The second book is called *Animal Psychology* (Fig. 2), an essentially inappropriate title, but stipulated by the publisher. It should be named "Behavioural Biology". The 48 figures, nevertheless, refer to behavioural patterns, orientation and special issues of behaviour. For the understanding of behaviour, concepts had priority such as for current instinct actions, terms coined by William H. Thorpe (1902–1986, Thorpe 1951) and Robert A. Hinde (1954a, 1954b), the SAP – 'specific action potential'. The ethological term 'drive' is differentiated here into the instinct actions and appetitive behaviour proceeding into a consummatory action as formulated by Robert Hinde (1953).

Now, the new quality of labelling behaviour should be mentioned which replaced the former psychological way of describing behaviour with the one of 1956. Part of it includes the theory of strata (theory of layers), developed as early as in 1949 (Tembrock 1949b), which later on is underlying many representations as 'encapsis' represented by a 'bowl model' whereas the fields are made smaller and put one on top of the other (see Fig. 3). Within this context subject-related terms also appeared in my work. It becomes apparent

1 The 'evolution' of the different books by Günter Tembrock is illustrated in a supplementary Figure provided by the editors (Fig. S1).

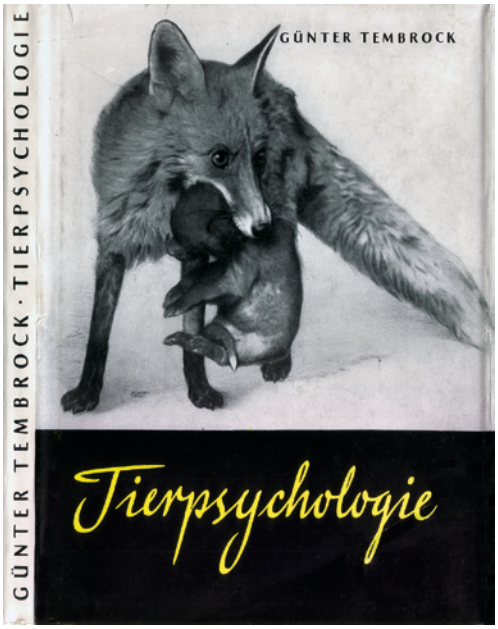


Fig. 2 Cover of the author's first book (1956) on animal psychology. The vixen carries a 23-day-old puppy in rigour (*Tragestarre*). (Photo by the author)

in the chapter "The behaviour of animals". The first figure shows a vixen (*Vulpes vulpes*) in a room displaying species-specific behaviour which in natural surroundings normally leads to burying remaining morsels of meat. Since here this was not possible two species-specific elements of behaviour ensued on the window-sill in the corner where pawing and thrusting were executed completely without functionally leading to any success (Fig. 4). Later on, we filmed this in the outdoor enclosure: After the highest ranking male fox had dug the hole the meat was removed by another fox. After hesitating briefly the male fox continued, closed the pit, covered it with soil and patted it with the tip of his muzzle. Such species-specific behaviour was measured and documented in 'ethograms' (or 'catalogues of actions'). These catalogues of actions were summarized and assigned to 'functional circles' (*Funktionskreise*), e. g. as 'behaviour caused by metabolism'. Behavioural biology is depicted by the following chapters: behaviour and sociology, behaviour and experience, pre-linguistic accomplishments, play, territory, animal and wo/man, psychoneuroses and stereotypes. Furthermore, ontogeny, research methods as well as neurobiology, sensory perception and vocal utterances were addressed. This array also represents our research concepts at that time. Up to 1958, 13 theses including 2 habilitations (post-doctoral qualifications) were completed within the framework of our research.

At that time acoustics gained in importance since from 1951 onwards we had a tape recorder at our disposal. The funds were justified by our proposals to include acoustic behaviour into our investigations and to establish an archive of animal sounds based on the level of tape recorder technique. In 1959, I published the first text book on animal sounds (Tembrock 1959, Fig. 5). Its complete title was: *Animal Sounds. An Introduction to Bioacous-*

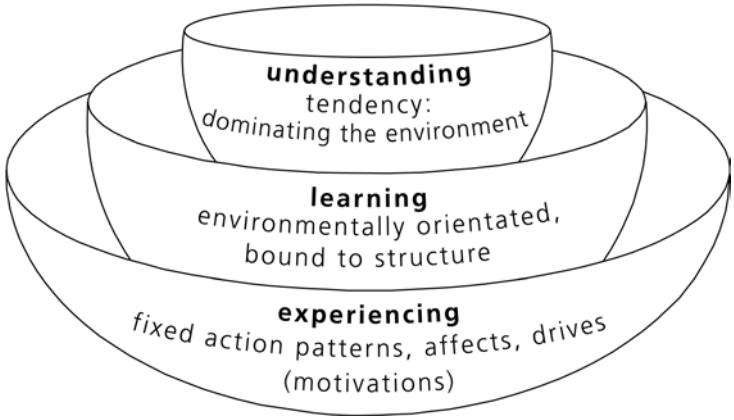


Fig. 3 Theory of Strata (Theory of Layers). The strata or layers form a hierarchical-encaptic system (encapsis). Encapsis means 'nesting' and we chose a 'bowl model' where each 'bowl' depicts a sphere which encompasses all smaller ones completely. This illustration states that for each embedded 'bowl' the properties or regularities, respectively, of the bigger bowls still apply. These properties, however, are now embedded in different framework conditions leading to a new quality.

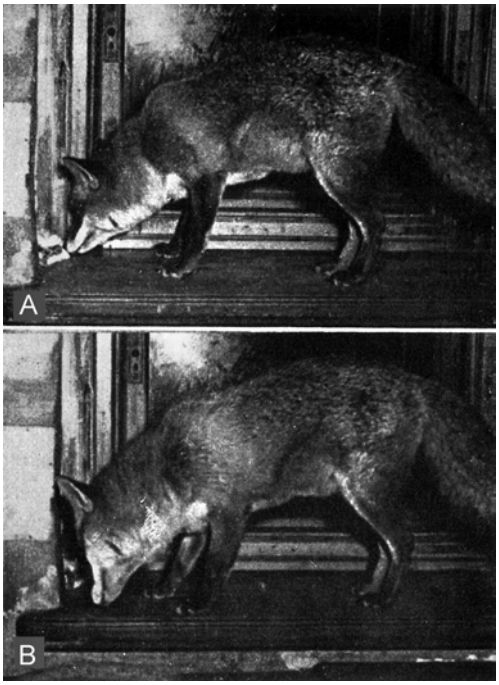


Fig. 4 A vixen of the red fox 'hiding meat'. The operation is performed completely despite of no apparent success: (*A*) shows butting with the muzzle, (*B*) shoving, but without soil as she would do under natural conditions. (Photo by the author)

Fig. 5 (*A*) Covers of the first (1959), and (*B*) the third (1982) edition of the text book on bioacoustics.

tics. The scientific approach fundamentally postulated that 'bioacoustics' contained producing of *and* listening to sounds whereas the international approach of 'biological acoustics' principally related to the 'voice of an animal'.

The concept of my presentation reflects the then scientific approach of our research indicated by our questions: relations between tones, complex sounds (clang) and noises, listening to and producing sounds, properties of species-specific sounds of animals, interior factors, sound and meaning, innate and acquired aspects of sound production, ontogeny and phylogeny, animal sounds and human speech, applied bioacoustics and methods. It becomes apparent that behavioural biology is the basis of this way of thinking. Thus, I probably offered the first introduction to bioacoustics as a lecture at a university (since 1963). Here, further new avenues were taken (from an international point of view): they are also combined with a first-time professional sound film for the university centre (Educational film: Tembrock 1958). The topic referred to comparative investigations on canids with regard to kinship as well as to the ontogeny of sound production of the red fox. At the International Conference of Ethology in 1957 I showed a film on the fighting behaviour of the red fox which triggered a lively debate by Konrad Lorenz. At that time we were internationally in the fore-run considering these issues, but we were systematically hampered by the university authorities concerned, combined with the cut of all financial support so that we could not keep the lead. Nevertheless, sound recordings were continued so that nowadays we belong to the three most comprehensive animal sound archives (see internet: www. tierstimmenarchiv.de). The construction of the Wall in 1961 resulted in the loss of

our last permanent position (Dietrich Ohm, 1924–2004), and he had to resettle at the Free University in Western Berlin where he engaged in particular in the gender-change of certain fish species.

Despite all the difficulties during that phase I continued my work. In 1961, the next book was published, the newly conceptualized ethology text book in German (Tembrock 1961). Its title read as follows: *Behavioural Science. An Introduction to Animal-Ethology*. It contains 114 figures which graphically illustrate species-specific, functionally-based and other issues. Additionally, it incorporates numerous figures from the literature. The main chapters deal with general ethology, systematic ethology, and experimental behavioural research. An odd era depicting the GDR: the text book was published, but the author of this discipline should not operate any longer. Just having been appointed a professor I was officially not allowed to supervise Ph. D. students which in fact I did unofficially.

In 1959, the vacant chair was filled with a nuclear biologist as the authorities were aiming at removing behavioural sciences from biology. However, I was appointed assistant director of the institute. The new director of the institute (Kurt Erdmann, 1907–1980) was meant to establish nuclear biology instead, but failed to do so. This period of the '60 years' encompasses the era of the zoological institute from 1959 to 1968 and the 'Third University-Reform' (*3. Hochschulreform,* i. e., reform of the higher education system) which led to the dissolution of the zoological institute as it was incorporated into biology. During my term as deputy director (1952–1959) there were two externally funded projects: the behaviour of guide dogs for the blind as well as behavioural concepts for deep-sea fishery. At the same time I initiated a cooperation in neurophysiology (which already existed in Berlin) in alliance with Hans Drischel (1915–1980, University of Leipzig). In connection with the concepts developed until 1959 my field of research within the zoological institute was summarized into three sections under the notion of 'behavioural sciences':

(*1.*) Communication, from insects to primates (with focus on bioacoustics).
(*2.*) Neuroethology.
(*3.*) Selective questions: reinforcing effects in schools of fish; behaviour of schools of fish under time-dependent stimuli; motor activity of golden hamsters under high voltage (externally funded projects, model for humans).

These activities and behavioural research led to us being assigned by the Ministry of Science and Technology to the 'Main Research Area Cybernetics' (biocybernetics), in the Central Working Group 'Human and Animal Physiology'. Under these given premises I could take on in 1968/69 the directorship of the former zoological institute together with the professorship as 'Department of Behavioural Sciences' to which I added unofficially 'zoology' in parentheses since we had to look after this field as a basic education, too (including medical students). Thus, during my term of service the behavioural way had been secured as the only one in the whole GDR. Despite certain SED (party)-functionaries – known to me – who caused many problems I was able to develop the scientific concept according to my own sense. The dynamics of my scientific development have manifested themselves in continuing the preparation of the overviews the last one having been presented in 1961. For the next book again animal psychology was requested as a title: *Principles of Animal Psychology* (Tembrock 1963). To deal critically with this term a 'history'

is placed in front and the 'psychological' was discussed separately. I can refer to still being persecuted by it. Instinct and experience are logically intertwined. The concept is coupled with the following aspects: the term of instinct, the physiological base of instinctive behaviour, the performances of receptors, central coordinations, obligatory learning, the problem of plasticity, subjective phenomena, genetic bases, orientation in space and time, pre-linguistic performances. The new way of thinking becomes apparent, resulting in the principal separation of 'facultative learning' and 'obligatory' behaviour. In 1968, my book titled *Outlines of Behavioural Sciences* is published (Tembrock 1968), coining a permanent term which the university chose as a title for the 'zoological institute' during the Third University-Reform.

Thus, the chapters chosen here also show the 'evolution' of behavioural sciences: 'the behaviour', 'motivations', 'releasors and releasing mechanisms', 'regulatory principles' (here biocybernetics), 'adaptation of behaviour', 'evolution and behaviour'. This concept suggests to bring into focus major relationships which form a hierarchical-encaptic system: the 'world' of humans (noosphere) presupposes the biosphere (the 'life') originated billions of years ago and this in turn the geosphere linked with the rules of the solar system which shows properties called self-organization (Fig. 6, see also Fig. 15). Thus, at an early stage defining 'life' became the request. The origin was and is the attempt to proceed from two elementary aspects:

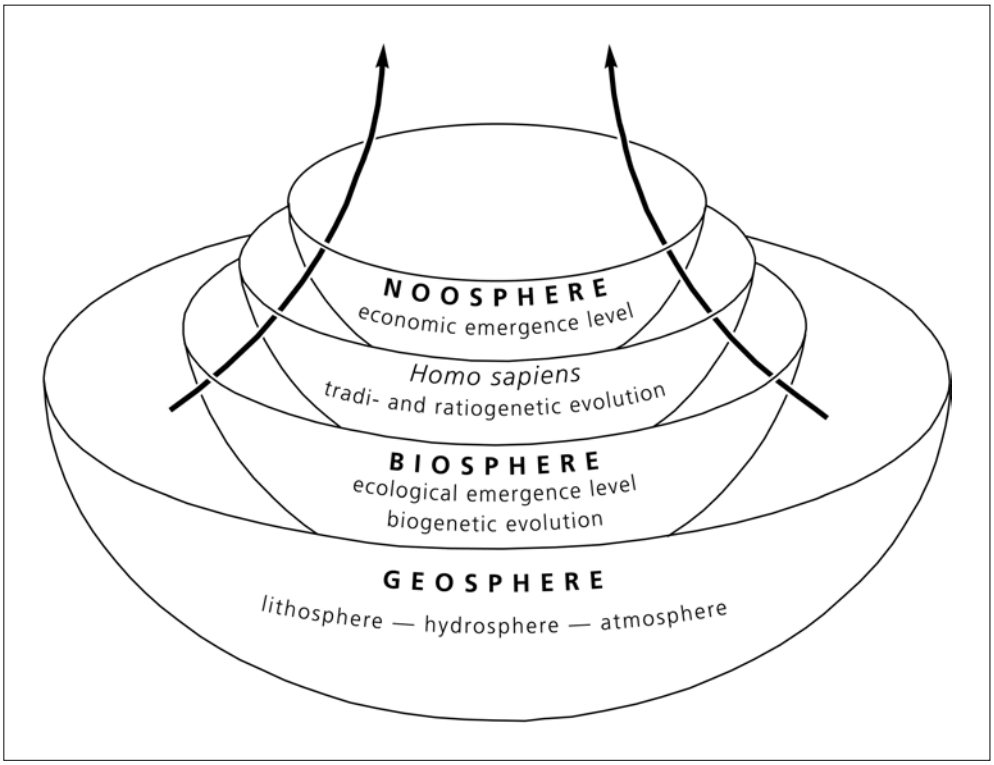


Fig. 6 Levels of emergence in the process of self-organization

(*1.*) Living beings are individuals (organisms);
(*2.*) Living beings are constituted of three basic characteristics that represent a functional unit: information exchange, metamorphosis and metabolism (I coined the term 'information exchange' – *Informations**wechsel*** – according to the German terms of

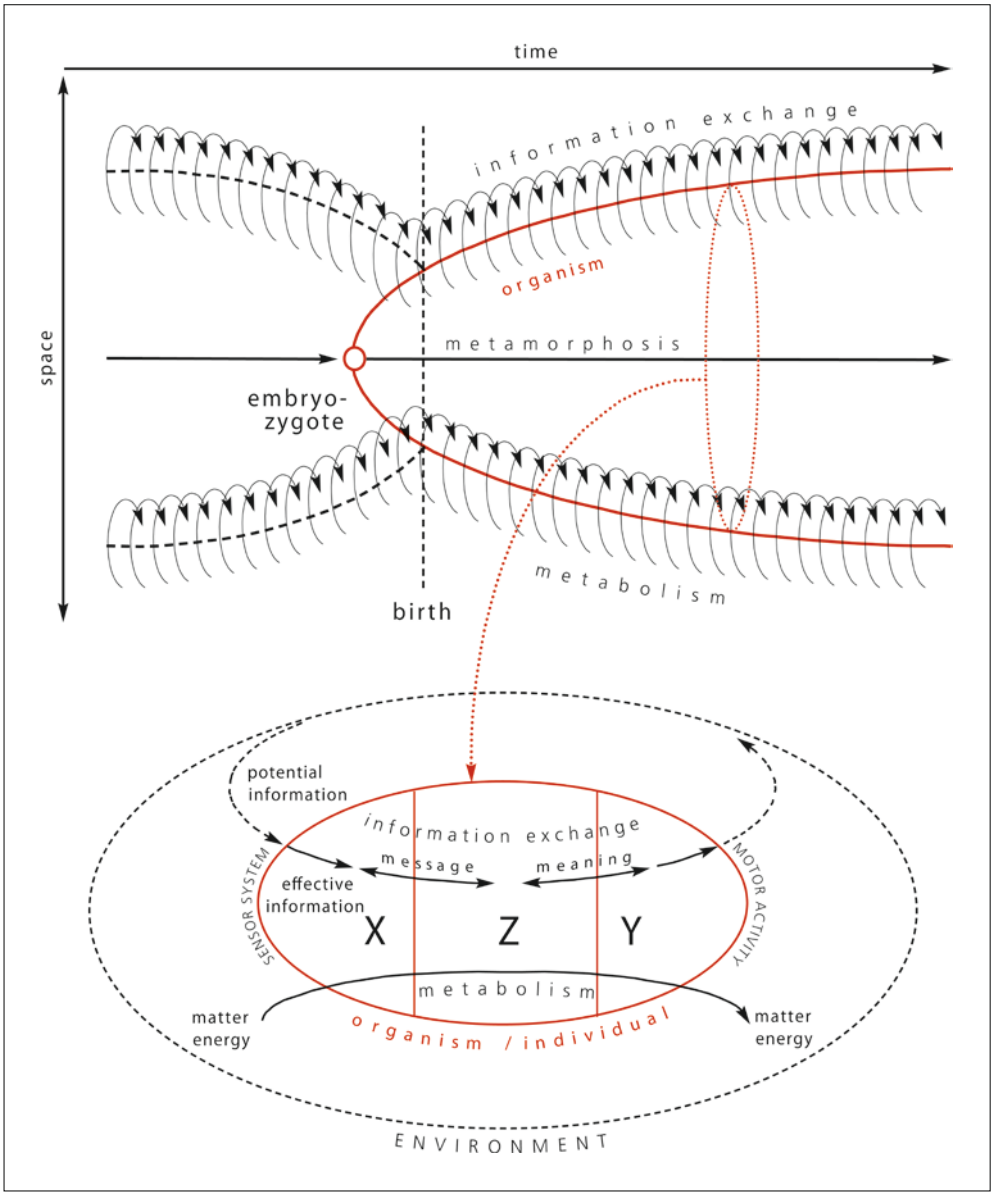


Fig. 7 Organisms become 'subjects' by common effective properties: metamorphosis (physical characteristics), metabolism and information exchange, the last two linking the 'open system' with the environment. Below are the 'three vectors' of the organism depicted which 'organize' its behaviour. (Modified from Tembrock 2003.)

*Form**wechsel***, metamorphosis, and *Stoff**wechsel***, metabolism) (Fig. 7). These properties coalesce with individuality ('mortality') and reproduction. The information exchange is based on the singular quality of what we call 'life' with the ability to store information (genes, genomes) and the informational relationship between organism and environment (*Umwelt*) (Fig. 8).

The concept assumes a dualistic structure of organisms where the subjective parameter is ascribed to quantum physics (Fig. 9). As a consequence, special representations developed during the application of the 'three-vector-model' (Fig. 10). The input vector (sensorial and material input), the internal state vector (stationary dynamic state) and the output vector (motoric and material output). During the phase after 1963, however, 'classical' methods were addressed such as research with mazes. These investigations were also interpreted physiologically. The approach is virtually a continuation of efforts to conceive 'behaviour' in all its facets.

From the very beginning (1949), the books cited here have been indicative of a comprehensive concept of behaviour – however named – having been in the focus of attention, and as a consequence a corresponding study group had been built. When in further

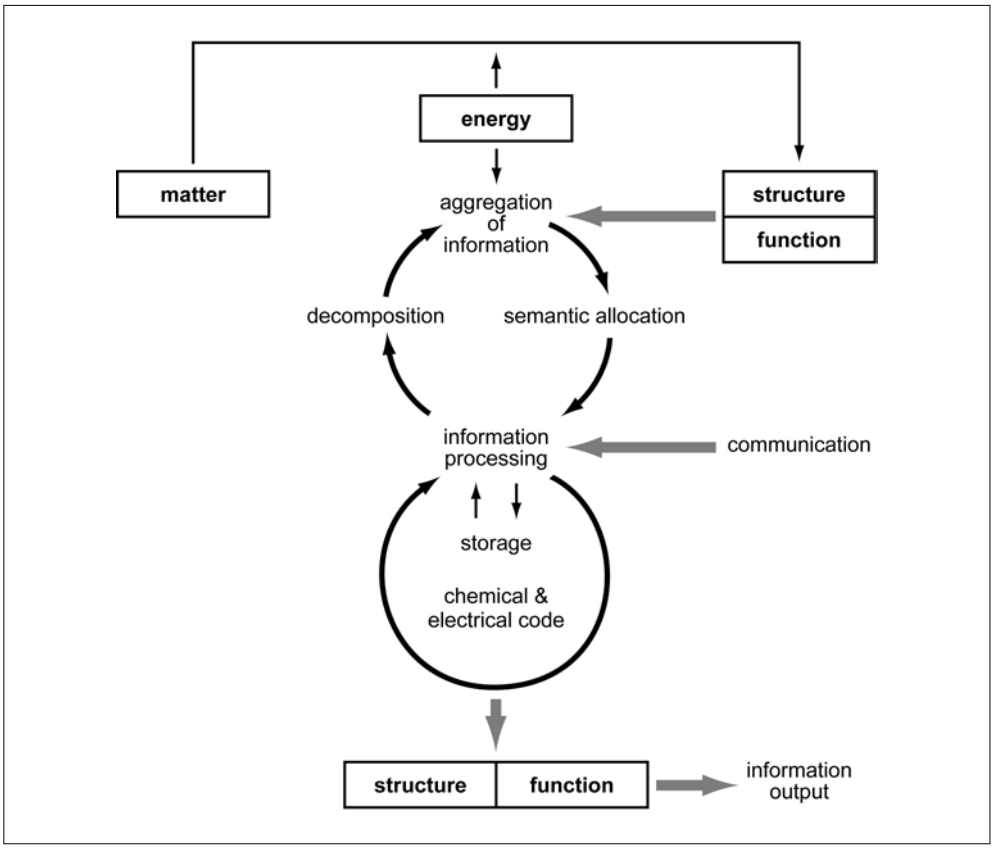


Fig. 8 Scheme of the process of information exchange

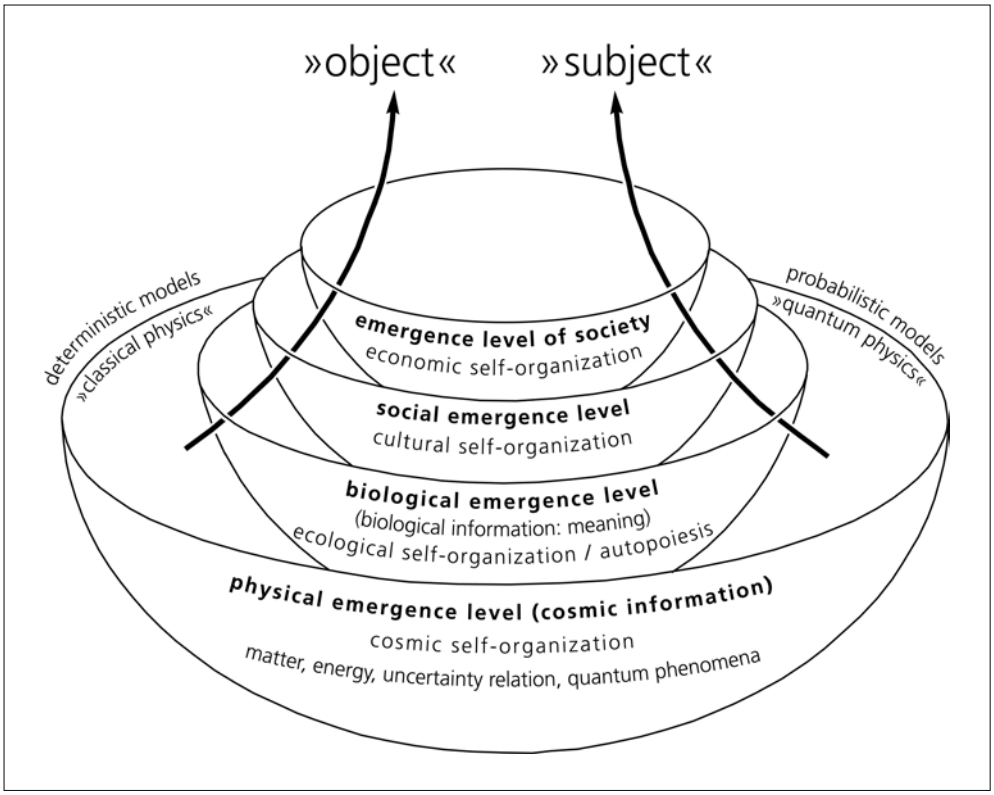


Fig. 9 Illustration of levels of emergence underlying the presentation. 'Emergence' stands for the formation of something new, more precisely the development of a new quality. The levels shown here embrace the following in the sense of an encapsis. 'Object' stands for observed properties, 'subject' for the 'observer' (a living organism). (Inspired by approaches from Görnitz and Görnitz 2002, and discussions thereafter.)

years a discipline was installed at a university then in conjunction with a head of department who would focus on a special topic. The research approach developed here in 1948 ran another path, and the books reflect the conceptional background. Hence, it has become discernible that there have been many obstacles, but the groundwork remained. Within the already mentioned department of behavioural sciences (1971) the structure of research of my chair was such: it consisted of two sections: (A) 'information exchange' und (B) 'system analysis (communication)'. Group (A1) with the emphasis on information transmission, behavioural algorithms, information aggregation, in each case altogether 15 people dealing with special topics mostly doing their theses. In this group I was also actively pursuing research concepts. Group (A2) comprised 5 people having the overall issue: recognition of signs and patterns. The remaining groups belonging to section (B) were divided into three 'sub-groups': fishes, insects, and mammals, where 19 persons participated, three external associated scientists included. These teams originated in 1968/69 within the context of the Third University-Reform resulting in completely different working structures which nevertheless upgraded my position at the same time to such an extent that I had a share in the further implementation of scientific-administrative matters on higher levels, too. Our

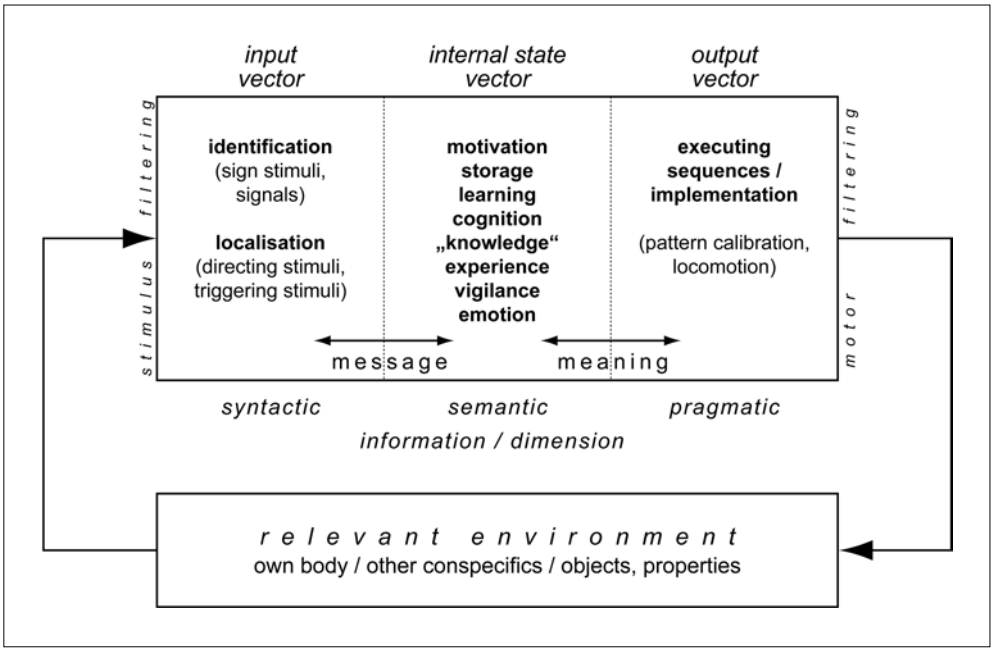
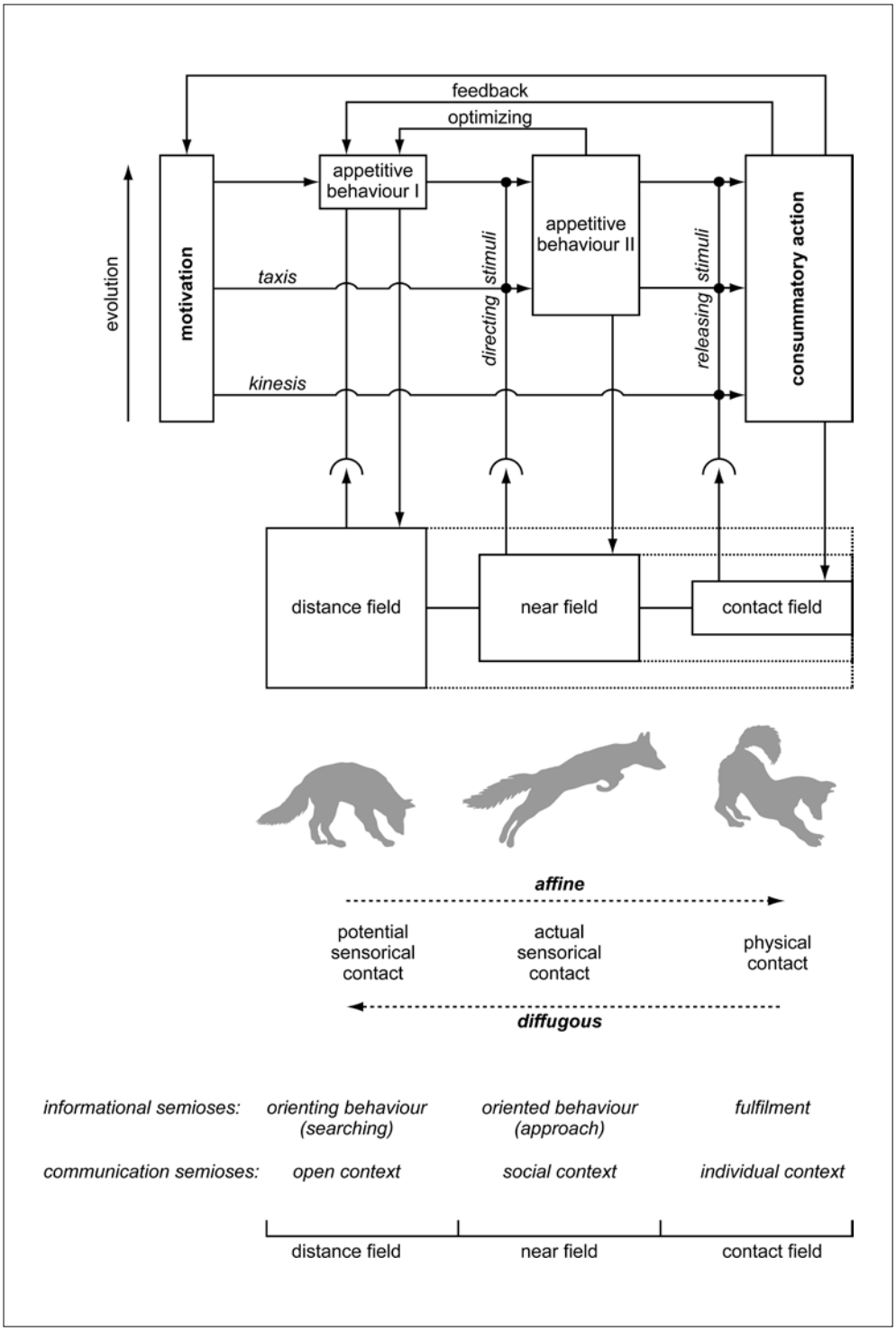


Fig. 10 Three-vector-model. Illustration of the structure of organism-environment-interaction on the basis of motivated behaviour that determines the aims (relevant environment) of the process. Three vectors can be distinguished within the organism: input vector, active information perception; internal state vector, information processing using and expanding contents of storage; output vector, motor activity in a wider sense, including vegetative phenomena.

thoughts repeatedly included synopses referring to major causal relationships last not least to the importance of the noosphere (Fig. 6, see also Fig. 15). The level talked about here and the overriding issues culminated in a singular book: *Biocommunication: Information Transfer in Biology* (Tembrock 1971). This book appeared in 1971 on the basis of information theory which led to my independent definition of an organism having three premises: metabolism, information exchange and metamorphosis as a functional spatial-temporal unit from bacteria to humans (Fig. 7). The information exchange may also mean communication.

Fig. 11 Three-phase model of motivated behaviour. Motivated behaviour aims at ensuring the fulfilment of a specific motivation by implementing adequate consummatory actions following appetitive behaviour. This model permits to distinguish between three 'fields of events' of behaviour (*Ereignisfelder des Verhaltens*). The distance field is defined by the condition, that there are no releasing stimuli present which could release the consummatory act (thus, orienting behaviour is activated). Internal factors, e. g. search images, may be guides for implementing the strategy of orienting behaviour. The near field is characterized by directing stimuli meaning that the goal was identified, as well as its position in space (thus, oriented behaviour is possible). Complex strategies have been evolving being enriched in many species by learning. The animal can only seek for those things about which existence it has 'knowledge'. Intra- and inter-individual variations of motivated behaviour on all levels help to optimize this strategy. The consummatory act, e. g. eating, results in a negative feedback on the initial motivation. We have to assume that these phases of motivated behaviour appeared in evolution in inverse succession, as seen in many cases in the ontogeny of individual behaviour. (Modified after Tembrock 1980, 1982a) ►


feedback
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motivation
evolution
taxis
kinesis
directing stimuli
releasing stimuli
distance field
near field
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affine
potential sensorical contact
actual sensorical contact
physical contact
diffugous
informational semioses:
orienting behaviour (searching)
oriented behaviour (approach)
fulfilment
communication semioses:
open context
social context
individual context
distance field
near field
contact field

A so-called three-phase model of motivated behaviour led to the definition of three 'fields of events' of behaviour (*Ereignisfelder des Verhaltens*) (see Fig. 11). Relating to the stimuli with respect to the distance (in space and/or time) the three fields can be termed as distance field (out of direct, immediate, but within possible and known reach), near field (within sight, hearing and/or smelling distance), and contact field (body contact). In the 1950s, I developed a concept dealing with intraspecific distance regulation. Certain behaviour elicits distance reduction which I named 'affine'. Distance increase I called 'diffugous' and its maintenance within a certain distance 'intermediary'. These fields and their

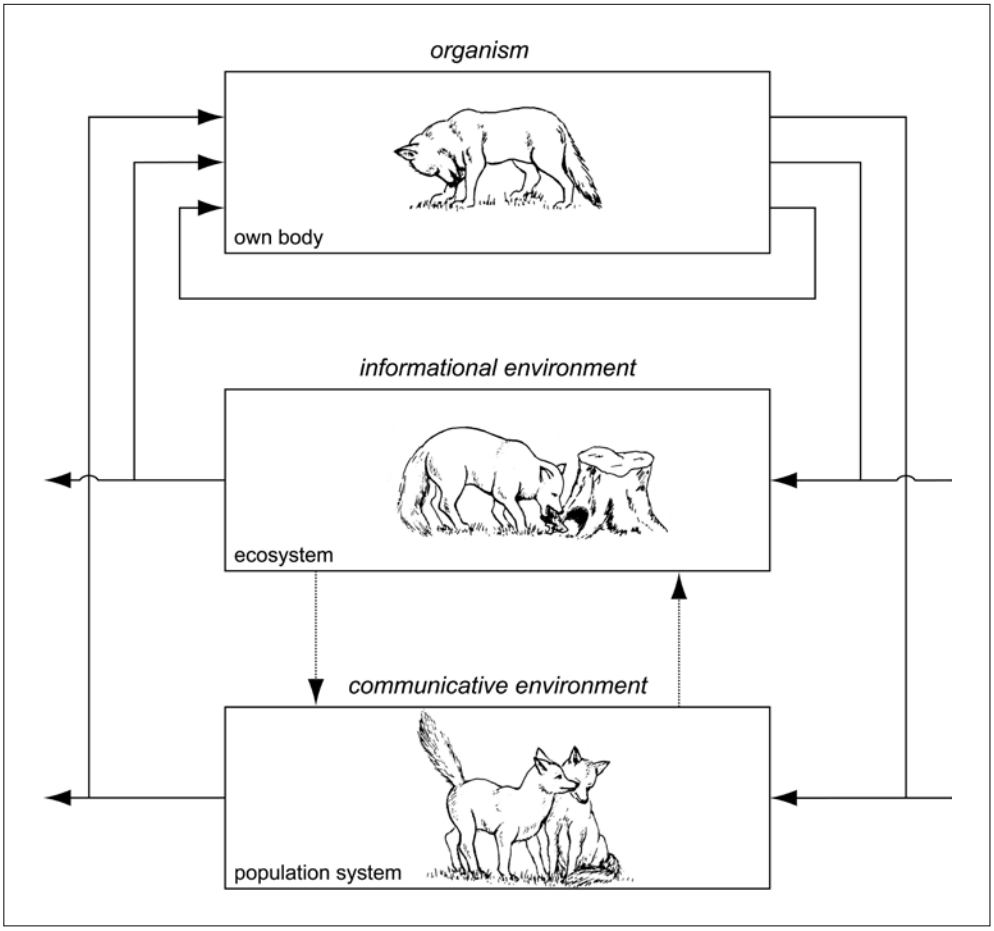


Fig. 12 Schematic illustration of the 'three environments' of the organism. The informational environment is a precondition for information exchange and the structure of organism-environment-interaction built on it. The 'Eigenumwelt' is defined by the own body's constitutional properties, these may be sources of information as well as targets of output behaviour, e. g. when grooming. Sources of information as well as targets of output behaviour lying outside the own body constitute the informational environment ('Fremdumwelt', ecosystem). All information is structure-bound the meaning only being assigned by the receiver. For the communicative environment (population) all information is bound to communicative signals, the meaning already assigned by the sender and therefore 'understood' by the 'addressee'. Some of these signals may be constitutional properties of the sender, others – which are commonly available in greater diversity – operate on the efferent level.

characteristics also define conditions of communicative behaviour. The environment relevant to the organism can be divided into three categories as shown in Figure 12.

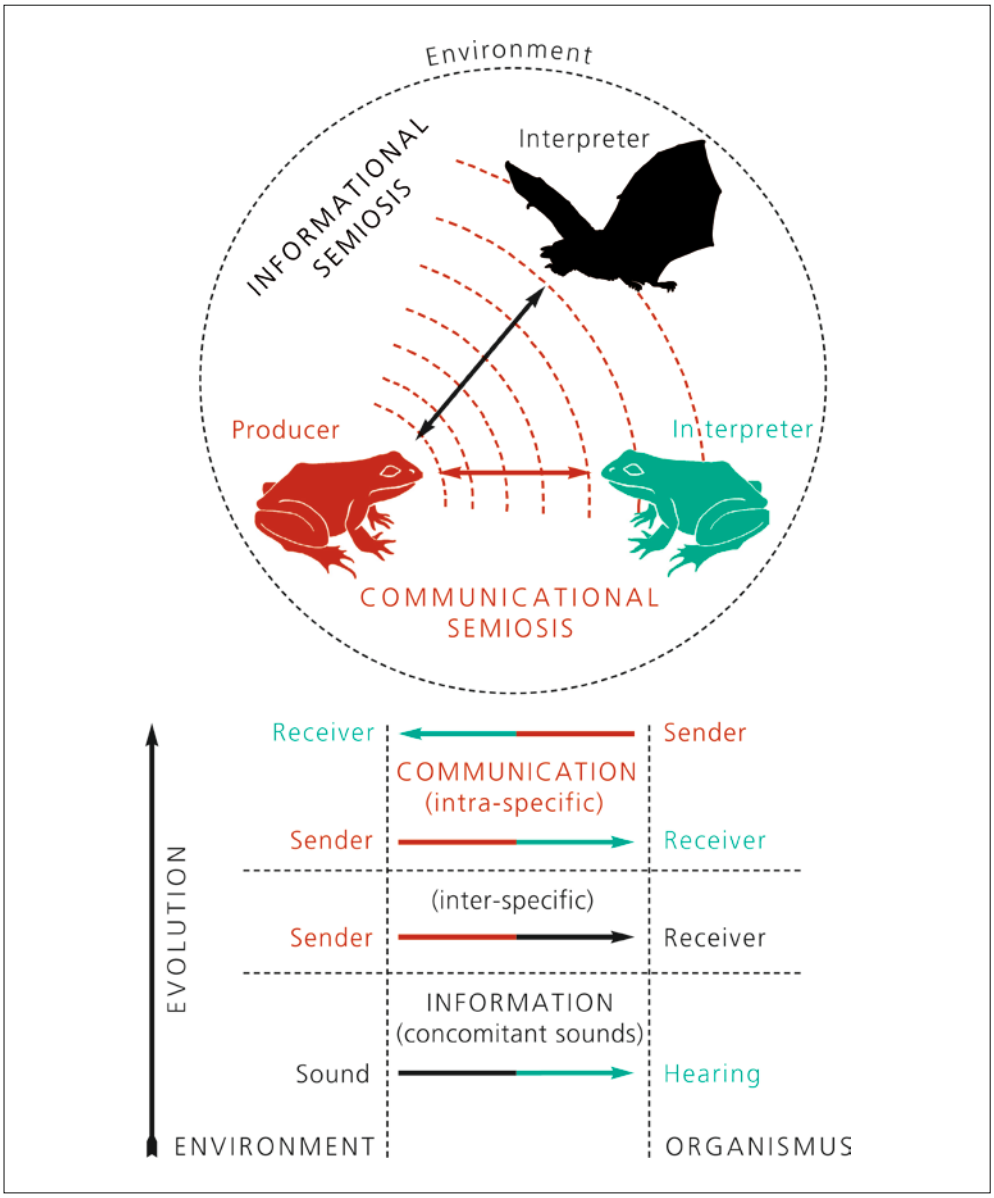


Fig. 13 Semiosis stands for information transferred by signs. The producer is the source of signals, the interpreter the receiver. Within a communication semiosis the male Tungara frog sends acoustic signals to the females (and possibly to competitors). Communication is given when there is a sender and a receiver both assigning the same meaning to the signal/sign (i. e. 'understanding' each other). The fringe-lipped bat here uses the calls as signal for identifying potential prey, i. e. not as 'subject' but as 'object' with certain properties. Thus, an information semiosis came about. The same applies to humans watching without understanding the subjective process between the frogs.

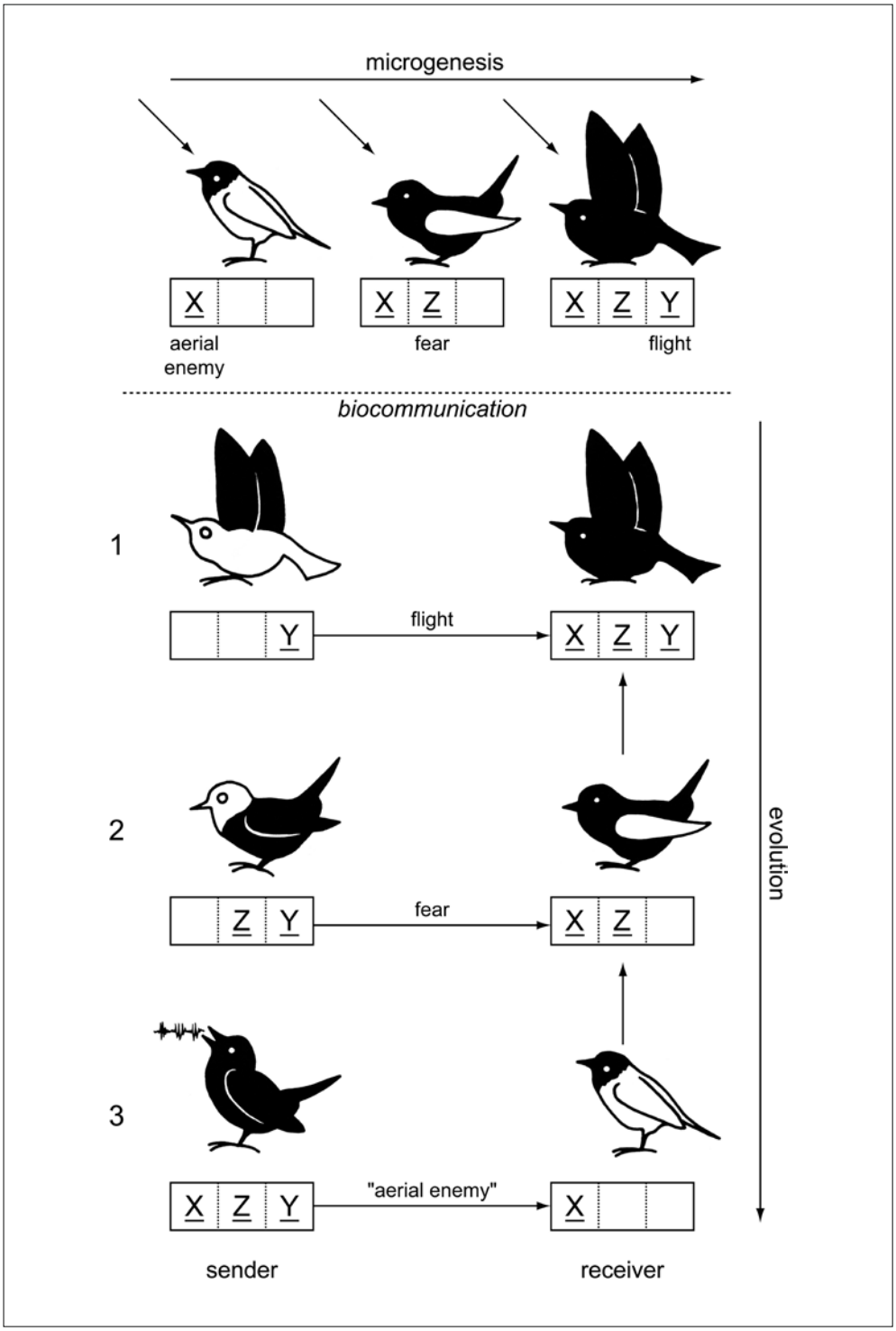
These approaches led to the following concept in 'biocommunication': fundamental issues of communication, physiological issues, genetic issues, phylogenetic issues, chemical, thermal, electric, mechanical, visual information transfer, complex systems of communication, general considerations and models. An impressive example is the frog sending communication signals to conspecifics and whose calls are used by a bat species for prey catching (Fig. 13). When applying the 'three-vector-model' within this context, one may deduce phylogeny and ontogeny to basic steps (Fig. 14). Against this background semiotics became an essential part within the context of information, which later on I integrated as a contribution about ecology to an encyclopaedia (Tembrock 1997).

Nevertheless, at that time already 30 years of many-layered developments had passed so that an institutional state within the framework of behavioural sciences had stabilized. In 1968, the elementary sentence can be found: "Ethology is the science of natural behaviour. [...] The natural behaviour of animals is the result of phylogeny."[2] At that time I developed the 'three-vector-model' for the behaviour of the individual which – refined – is still valid today (see Fig. 10) (Tembrock 1974). About ten years later I took on Friedrich August von Hayek's (1899–1992) concept (see von Hayek 1979) and extended it substantially whereas his three potentials relating to humans were differentiated as layers: biogenetic, tradigenetic and ratiogenetic potential. I added the evolutionary potential (Fig. 15). As an example this model can be applied explaining the acquisition of language (Fig. 16).

In this phase of development our work in progress focussed on overriding principles whereby having been accepted as a member of the Academy of Sciences Berlin (1975) was helpful. Among the first topics presented at the academy was: The 'optimizing strategy of behaviour' (Tembrock 1976). Organisms were regarded as multi-stable open systems with the following premises: homeostasis and behaviour, locomotion and orientation, metabolism and protection, adaptation on the basis of individual experience. Within this context 'fundamental issues of behaviour regulation' (Tembrock 1977) were covered in the acad-

2 Tembrock 1968, p. 11.

Fig. 14 Three steps of the evolution of biocommunication. The microgenesis of a motivated stimulus-released behaviour is illustrated: A passerine bird perceives a raptorial bird in the air. This means for him 'aerial enemy'. After this process of identification and designation as a function of the input vector (X), the internal state of 'fear' (Z), will be established in consequence, that means the bird is ready to perform a specific behaviour pattern. This leads in the output vector (Y) to a flight behaviour typical for this species. If we accept these general phases of the behavioural interaction with the environment, we can derive three steps of the evolution of biocommunicative behavioural processes: (*1*.) Transmission of the behavioural processes of the output vector (functional transmission), i. e., the output (vector) of the sender determines all three vectors of the receiver. The receiver executes the same behaviour as the sender, that may be an allelomimetic phenomenon, but it does not include a specific internal state. (*2*.) Transmission of the internal state by signals of the sender; in our example the readiness for flight behaviour. The signals designate the state of 'fear', or what we understand by this. The receiver is now in the same (internal) state as the sender (but without information about the cause of this state); he may show flight behaviour. (*3*.) Transmission of information about the sender's perceptions; in our example the 'aerial enemy', in some bird species indicated by specific acoustic signals. Here, the receiver is able to react as if the perception was performed by himself. This level of biocommunication builds up two principal degrees of freedom in the receiver: the choice of the internal state and the choice of the external (output) behaviour patterns. The upward-pointing arrows in the right column indicate each the possible (and adequate) subsequent behaviour. (Combined and modified from Tembrock 1980, 1985.) ►


microgenesis
X
X Z
X Z Y
aerial enemy
fear
flight
biocommunication
1
Y
flight
X Z Y
2
Z Y
fear
X Z
3
X Z Y
"aerial enemy"
X
sender
receiver
evolution

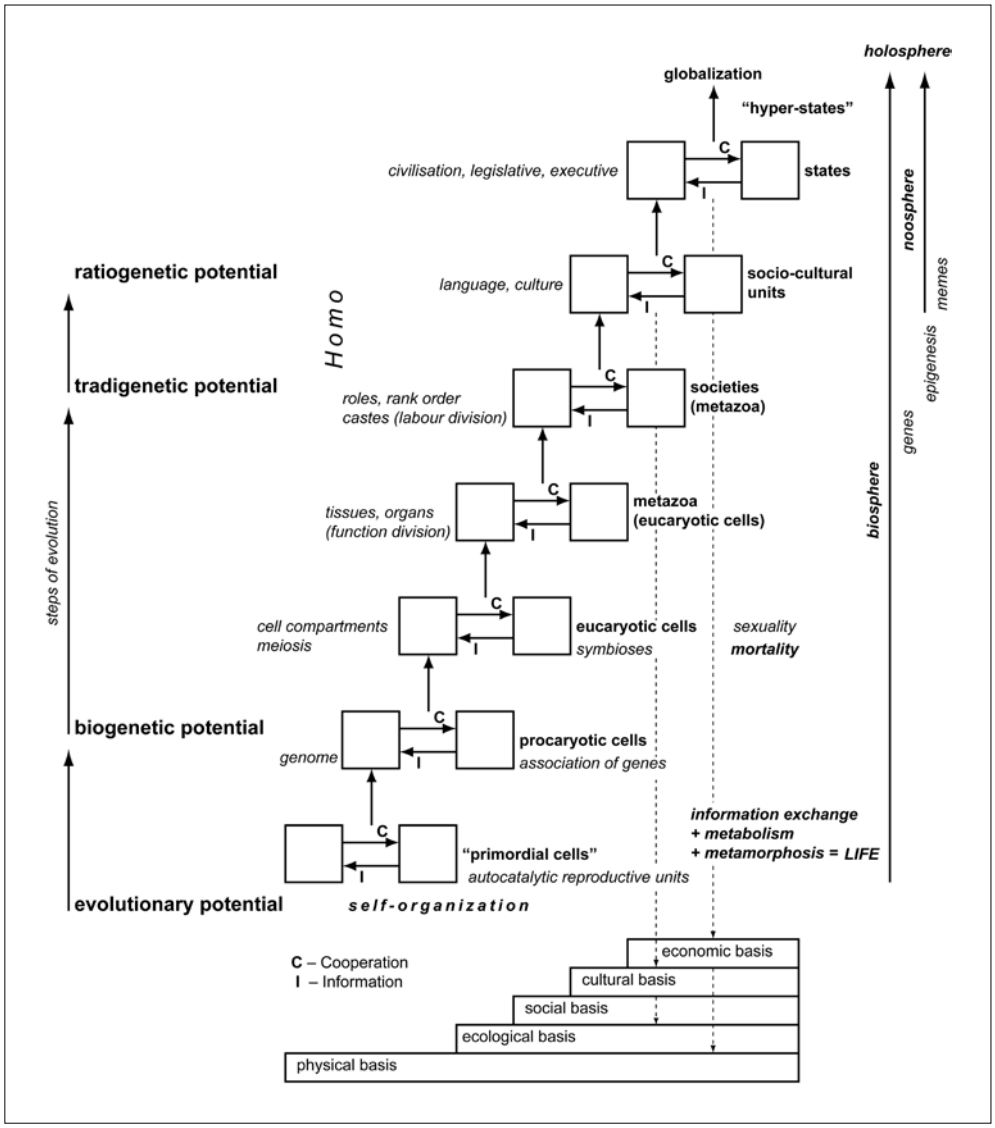


Fig. 15 Steps of evolution. Levels of hierarchies of elementary system parameters with regard to adequate environmental conditions determining interactions, self-organization and adaptation in the course of evolution (inspired by approaches from Müller 1987 and Oeser 1988). The two human specific levels are characterized by an own quality of consciousness, verbal communication and an autonomously emerging change of the 'basis'.

emy. It included a fundamental scheme of information exchange developed at that time as well (Fig. 8). The lectures at the academy of sciences are especially orientated towards perspectives. This also applied in 1977 to the topic of *Bioacoustics, Music and Language* (Tembrock 1978). The developing bioacoustical investigations led, apart from 'collecting' recordings of animal sounds, to comparative studies as parameters for assessing kin-

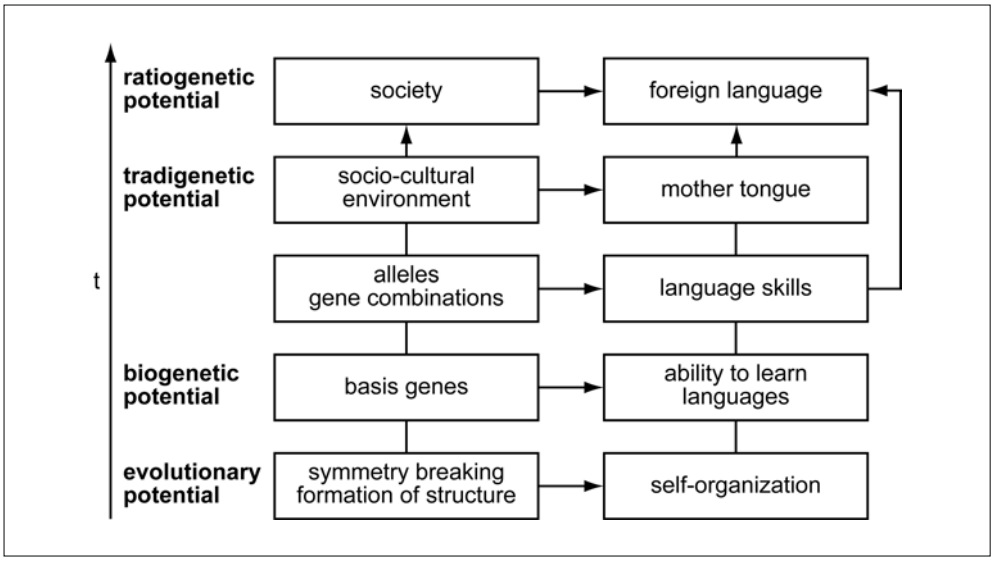


Fig. 16 Illustration of hypothetical levels of potentials which during the cosmogeny of our planet were superimposed on top of each other; the biogenetic potential coalesces with organismic evolution. An example on the right: the evolution of language.

ship, but included other topics such as comparative studies on humans and primates in relationship to the 'mechanisms' of phonation, too. In this context the following findings are shown: 'Bioacoustics as Science' investigates sound events under the following aspects:

(*1*.) Structure and function of sound production;
(*2*.) structure and function of sound perception;
(*3*.) biological sound as information (signalparameters: phonetics, metrics, sigmatics, syntax, semantics, pragmatics);
(*4*.) changes in time (individual, supra-individual, developmental aspect).

Our scientific way of dealing with animal sounds and communication was determined by some key aspects: in 1956, the 'International Committee on Biological Acoustics' was implemented at the University of Pennsylvania followed in 1959 at our institute by 'bioacoustics' which special structure was accounted for as a scientific concept labelled as 'sender and receiver'. I accentuated that when designing the cover of this book (see Fig. 5). In 1968, Felix von Trojan (1895–1968) employed after a longer contact with me the term 'Biophonetics' (Trojan 1968), discussions about the relationship of the animal and the human voice on a semantic level are reflected in my contribution to a later edition of the book (Tembrock 1975, see also Tembrock 1998b). There was another exchange of experiences with Klaus R. Scherer leading to his book about vocal communication including my contribution (Tembrock 1982b). Likewise, there were contacts with Nils L. Wallin (1924–2002) who denotes his basic approach with the term 'biomusicology' addressing a comprehensive concept: 'Neurophysiological, Neuropsychological and Evolutionary Perspectives on the Origins and Purposes of Music' (1991). Then, there was a longer relation-

ship rich in substance with Georg Knepler (1906–2003) leading to his *History as a Means of Understanding Music* (1977).

As a member of Leopoldina (since 1965) I participated in a symposium under an overriding concept concerning language: 'scientific linguistics' led by Joachim-Hermann Scharf and Wilhelm Kämmerer (1905–1994) in 1976, organised by nine representatives of the field: Bernhard Hassenstein, Gerhard Joppich (1903–1992), W. Kämmerer, Friedhart Klix (1927–2004), K. Lorenz, Detlev Ploog (1920–2005), J.-H. Scharf, G. Tembrock und Konrad Zuse (1910–1995). Seven topics were treated by competent representatives of different academic disciplines. Still nowadays, the volume comprehending 865 pages is a 'treasure trove' (Scharf and Kämmerer 1981). Topic III (Martin Lindauer [1918–2008] and G. Tembrock) dealt with 'non-verbal communication of organisms'. My contribution was named: 'signal systems of primates' (Tembrock 1981). Within this context own investigations on mimics of chimpanzees are illustrated. Special conditions have been postulated for primates leading to a complex communication as it is generally combined with social behaviour. The information may be transmitted *via* mechanical, optical and acoustic signals. The paper in question (1981) applied new representations: the subtleties of muscular movements of chimpanzees (mimics) becoming operant in expressional movements. These investigations were followed later on by another study on combinations of those optical with acoustic signals. One should consider that almost all species concerned here are active during daylight. Incidentally, I also included the human voice in this study and looked at an issue not yet examined till then: the age-related changes of the singer's voice particularly concerning the frequency of the vibrato which reduces 'at an older age' (around 60) from 6 Hz to 5 Hz, related to 1 second as long as the voice is still preserved as such. Formants remain constant, the upper harmonics change. The same phenomenon applies to the hand vibrato.

The continuous expansion of the collection of animal sounds increasingly led to working on special issues determined by behavioural biological concepts. Thus, my next book was titled *Behavioural Biology* (Tembrock 1987). An insightful result of these monographies of an author and his '60 years of behavioural history' which at that time emanated from a concept evolved during the then 39 years of applied scientific debate with our discipline at the Humboldt University. Thus, in 1987, behaviour was defined as such: "Behaviour is organismic interaction with the environment on the basis of an information exchange ensuring individual, ecological and inclusive fitness."[3] Three examples are: handling of objects, dealing with organisms and dealing with conspecifics. Another aspect denotes environmental behaviour. The behavioural physiological aspect is differentiated as follows: (*1.*) neuroethology and (*2.*) behavioural endocrinology. Ethology now exceeds far beyond the formal description, the comprehensive term is henceforth 'biology of behaviour'. In the book mentioned here concrete concepts for capturing parameters are deduced from parameters of behaviour. Thus, from those concepts dealt with here special questions emanated such as assessing the behavioural state from the heart frequency of a fish. What distinguishes this book from its predecessors is its introduction of tangible tools for research. Along with it, new questions arise for gaining insight into ecological, geographical, physiological, morphological, and ethological isolation mechanisms as well as gametic and post-zygotic ones. Of course, this also addresses evolution. As an impor-

3 Tembrock 1987, p. 15.

tant factor of evolution 'improvement of locomotion' is turned to as well as to the shifting from an axis to extremities, the evolution of the exoskeleton (arthropods) and the skeleton (vertebrates). Furthermore, it is referred to the evolution of birds from reptiles, a particularly impressive example for the ecologically orientated evolution of behaviour as concerns thermoregulation.

Thus, behavioural biology proves itself to be a behavioural science. Into this concept 'adaptation' is integrated. Terms like 'fixed action patterns' and 'ritualization' have their own significance: 'behaviour adapted for other purposes' ritualizes to 'signalling behaviour'. For the deduction of 'signalling movements' twenty different forms are defined. Thus, behavioural observations can be looked at under various aspects: observations, functional explanations. Consequentially, points of application may be deduced for selection, differentiated into group selection, individual selection and kin selection.

Another chapter deals with the physiological bases of behaviour. It is revealing to compare these developments with those already sketched in my book *Animal Psychology* from 1956. For the physiological illustrations the ground-breaking research of the developmental endocrinologist Günter Dörner (Charité Berlin) with whom I have been cooperating for a very long period has been incorporated.

Yet another chapter (1987) attends to 'motivated behaviour' including results of our research groups. A separate chapter was dedicated to the 'genetic presuppositions'. Another chapter addressed ontogeny. It is ethologically relevant to differentiate into 'nidicolous nestlings' 'altricial young' and 'nidifugous nestlings'. Humans are always included into these considerations. Generally, transformational phases, sensitive phases and imprinting are discussed. This illustrates the attempt to interpret behaviour in terms of behavioural science which covers all organisms.

Thus, 'phylogeny' follows in the next chapter as a result of natural selection. This also applies to general concepts of the evolution of behaviour. Here the notes of Charles Darwin from 1835 should be recalled: "When I see these Islands in sight of each other, & possessed of but a scanty stock of animals, tenanted by these birds, but slightly differing in structure & filling the same place in Nature, I must suspect they are only varieties. […] If there is the slightest foundation for these remarks the zoology of Archipelagoes will be well worth examining; for such facts would undermine the stability of Species."[4] Species are not unmodifiable, against this background the book mentioned here provided in 1987 the following concept under the notion of 'variability levels': (*1*.) Individual variability, (*2*.) Inter-individual variability, (*3*.) Regional variability (geographical), (*4*.) Species-specific behavioural variability, and (*5*.) Characteristics of different kinship. Within this context, learning processes and their relationships are addressed which I have already been differentiating into obligatory and facultative learning for a long time. The obligatory ones have the character of 'imprinting' and are bound to certain areas of the brain which does not apply to facultative learning. Imprinting processes are distinguished into three forms of imprinting: the *sensory imprinting* bound to the input vector, the *readiness for imprinting* operating on the internal state vector, and the *sensomotoric imprinting* which finds its species- and individual-specific implementation in the output vector (see Fig. 10).

Within this context one should also remind of the habituation usually termed 'adjustment' in colloquial language. The development of behavioural science is connected with a

4 See Barlow 1963, p. 262.

deepening and broadening of insights into the causal structure of observed processes which reveal even deeper insights *via* appropriate experimental set ups. In this regard we also conducted a range of investigations and experiments concerned with the three vectors ('input, internal state, output'). Again, these questions associate with a fundamental issue: the environmental requirements determining behaviour. They characterize the nature of 'life' as 'elementary requirements'. Thus, 'environmental requirements' and 'individual environmental requirements' and 'traditional (handed down) environmental requirements' concatenate. Individuals need to meet demands of space and time. They require contact space and locomotion space as long as they are not sessile. Swallows perching on wires keep a minimal distance from each other which allows them to fly off unimpeded.

The description addressed here shows that it was a long way till then to comprehend 'behaviour' in its inner causality. Against this background numerous special topics were investigated such as the swarming behaviour of fish whereby the issue of 'temporal demands' led to special studies, within the particular context of the 24-hour-rhythm as well as the annual rhythm. From very early on, chronobiology engaged me in taking my first recordings of toads and ground beetles from 1943 onwards.

In the book of 1987, the notion of 'functional cycles' having already been developed before that period is used, functional cycles are defined ethologically, they ask for cause and effect. In that book functional cycles are classified according to the behaviour: orientational behaviour, metabolic behaviour, protective behaviour, burrowing behaviour, intraspecific competitive behaviour, migratory behaviour, reproductive behaviour, biosocial behaviour and play behaviour. This concept also underlies the book comprising over 1000 pages, and 5160 references, which I prepared with regard to the evolutionary aspect under the title *Systematic Behavioural Biology of Animals* (Tembrock 1983) and which 'illustrates' behavioural biology with 553 figures. It was a long way leading from *Animal Psychology* in 1956 to this *Systematic Behavioural Biology* in 1983. This book was supplemented in 1984 by the title *Behaviour in Animals* equipped with 110 figures, complemented on the background of our numerous study groups and again presenting 'up-to-date science' (Tembrock 1984). A completely new chapter was named: "Animals and Humans". Also, the attempt is taken to process the array of aspects regarding their relationships. Hence, complex questions arose leading to special investigations. In those general representations of 'Behaviour in Animals' a range of studies from co-workers is included such as research on grooming. Special questions on the 'mimic' expression of mammals were examined. Relationships between 'human – animal' were classified in (1984) as follows:

(*1.*) Meaning of humans to animals: 'enemy', 'prey' (rare), 'hosts' (ecto- and endo-parasites), 'environment' for certain species, 'biosocialpartners'.
(*2.*) Meaning of animals to humans: 'enemy', 'prey', 'parasite', 'carriers of diseases', 'commensals', 'beneficiaries', 'nutrients', 'symbionts' (mutual beneficiaries – bee, dog, cat), 'partners' (working animals), and yet an extensive topical range: 'animals as objects of satisfaction of special needs'.

Within this context another concept was developed leading to new study groups: 'behaviour as bioindicator' (1989, see Tembrock 1990). An issue of that time was 'stress reactions' with the following emphases:

(*1.*) Modification of spatial and/or temporal relationships with regard to the source of stress;
(*2.*) application of constitutional properties of the body in connection with motoric patterns;
(*3.*) alteration of attributes of the environment.

Within this range processual spheres of action can be distinguished:

(*1.*) Effects on the body and its constitutional properties: (*a*) species-specific, (*b*) gender-specific und (*c*) individual-specific;
(*2.*) effects of behaviour within the framework of interactions with the ecological niche in the context of using resources;
(*3.*) effects on behaviour within the framework of interactions with the conspecific population in the context of signalling behaviour and biosocial functions.

Single individuals are subject to varying stressors on the processual sphere of effects: the processor intervenes directly in the course of behaviour; the stressor intervenes in the physiological causal mechanisms which makes the actual course of events possible.

'Ethostressors' and 'sociostressors' were used for data assessment, e. g., by exploring indicative valences of 'decisions deviating from the rule'. Within this context our working groups arose being stimulated by my concepts. First investigations on humans regarding this topic were done by Michael T. McGuire. From our own research an array of possibilities of bioindications was deduced.

The chapter headings of the second edition of *Behavioural Biology* (1992) had moved on to the following topics: (*1.*) The science of behaviour, (*2.*) Methods of behavioural biology, (*3.*) General characteristics of behaviour, (*4.*) Physiological principles of behaviour, (*5.*) Motivated behaviour, (*6.*) Behaviour and adaptation, (*7.*) The environmental requirements determining behaviour, (*8.*) Functional circles of behaviour, (*9.*) The environment and the array of effects, (*10.*) Functions of behaviour, (*11.*) Applied behavioural science, (*12.*) Behavioural biology and human sciences. This includes 65 'sub-chapters' showing how the 386 pages are structured.

Generally, the data collection during all those years was done under the following premises:

(*1.*) wild animals in their natural habitat;
(*2.*) wild animals in an anthropogenously 'influenced' habitat (e. g. most forests in industrialized countries);
(*3.*) wild animals in an anthropogenic habitat ('synanthropic species') (e. g. influenced by agriculture);
(*4.*) wild animals kept by humans (e. g. zoos),
(*5.*) wild animals bred by humans (e. g. zoos),
(*6.*) domesticated animals kept and bred by humans (e. g. husbandry).

A special topic, zoo-biology has been termed an 'integrative science' with the components: 'arts (ideographic science)' and 'science (nomothetic science)'. This results in three dimensions of competence:

(*1.*) cognitive (rational) competence,
(*2.*) aesthetic competence,
(*3.*) ethical competence.

These are the conditions for an 'integrative educational mandate'. Zoos are public establishments, thus, humans belong to them in two completely different functions:

(*1.*) caretakers, researchers of the zoo animals;
(*2.*) visitors of zoological parks.

Within this context the 'working group zoo-biology' developed in 1993/94 the following concept of 'animal-appropriate and species-appropriate requirements' on keeping conditions in zoos:

(*1.*) 'Species-appropriate' emanates from the biological species in the sense of Ernst Mayr (1904–2005). Members of a species form a reproductive community. Individuals of a species recognise each other as potential partners. The species is a genetic unity coming from a large gene pool with mutual relationships. Consequences for behavioural biology ensue.
(*2.*) 'Animal-appropriate' ensures individual fitness within the context of species-appropriate premises whereby parameters of individuality, of keeping conditions may lead to ethological modifications.
(*3.*) Tasks of species conservation require both levels.
(*4.*) A fundamental significance is assigned to ontogeny within the sense mentioned here (ontogenetic parameters).

A basic contribution dealt with the issue of zoos of today and tomorrow (Tembrock 1994).

Another point that should be referred to addresses the model of dualistic evolutionary strategies I developed in the mid-nineties inspired by the ideas of Gerd Binnig (1992, see Fig. 17) thereby hoping to stimulate thinking along the following lines. Strategies of replication (= strategies of performance) run in cycles, strategies of storage change internal states and internal selection processes, too. Each cycle of reorganization reinforces asymmetry with the increase of the complexity of internal storage patterns. Asymmetry creates a 'past', changes the cycles of the replication strategy into spirals and thus constitutes a 'quantization of time' intrinsic to the system which is experienced as 'subjective time' by humans with a consciousness capable of reflection.

For the development of the "60 years" it is characteristic that not only the collection of animal sounds has been constantly expanded and developed and that it is still active (Frommolt 1996, 2008, see internet: www. tierstimmenarchiv.de), but that academic work could develop further due to the expansion of technical possibilities. Furthermore, other disciplines took notice of us so that I was invited to give talks at the 'Stuttgart Voice Conferences' ('Stuttgarter Stimmtage') from 1998 onwards on topics such as 'Parameters of the Voice within the Social Context – a Comparative Consideration' (Tembrock 2000b). For the evolution of acoustic communication which includes humans, three functional fields can be distinguished: the contact field, the near field and the distance field as related to the voice (see Fig. 11). In the paper concerned (Tembrock 2000b) the following statements were made:

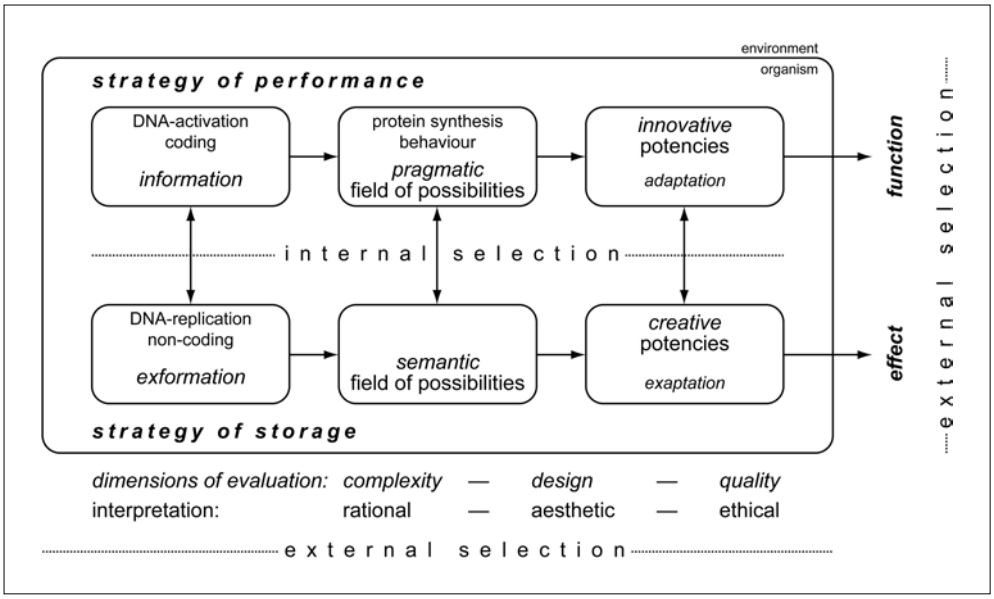


Fig. 17 Dualistic model of evolutionary strategies inspired by a hypothesis of Gerd Binnig 1992

(*1*.) The 'communication dyad' (within the contact field): sender–addressee/–receiver (all known to each other, the addressee being meant, but another receiver possibly also getting the message) is often linked with substance transfer (mother's milk, food, sperm cells) or with other behaviour in body contact.
(*2*.) The intra-social communication (acoustic, visual, olfactory) within a social group (all known to each other), i. e., the near field ensures the perception of other individuals.
(*3*.) The distance field is given when there is no actual contact between social partners, but communication could be established.

Baboons have 'hominoid' sounds reminding of humans and also denoted as 'primeval sounds'. In this context one can mention the human non-verbal 'filling sound' (*uh*) while talking. Of particular interest is the fact that in mammals neonates utter similar sounds. My book on the acoustic communication of mammals (Tembrock 1996) joins widely varied investigations on acoustics (among them the 'Stuttgart Voice Conferences' till 2004, see Tembrock 1998b, 2000b, 2002, 2004, 2006a) which comprehend a broad research array of the voice, supported by studies on animal sounds.

In 2000, I wrote a book covering the issue of *Angst: Natural History of A Psychobiological Phenomenon* (2000a). The concept is orientated towards the following questions: neurobiological view, behavioural view, individual state, social phenomena, ecological context, dimensions of "angst", developmental aspects and the way to human beings. About 40 years earlier (1961), I put emphasis on clearly separating "angst" and "fear": abridged, "angst" means a behaviour that cannot implement species-specific behaviour when in danger, whereas for "fear" species-specific behaviour is available.

We are approaching the "keynote", the "60 years" which were reached in 2008. Here it becomes obvious that this era was determined by comprehensive issues keeping science and arts within their view, and with it the noosphere and a global view. For that matter the *Journal of Human Ontogenetics*[5] has been created, its introduction by the editors-in-chief was formulated thus: "The central idea for human ontogenetics is the methodological concept of the unity of complexity and time (in the sense of Prigogine), which demands considering the complexity within the light of the *'eigentime'* (*Eigenzeit*) of the 'system human being'."[6] The first contribution begins with this formulation: "The concept of the science about humans presented here abolishes the traditional gap between science and humanities. The foundation is a universal concept of development that assumes an evolutionary potential of self-organization as a precondition for the biological potential on our planet to which the biosphere owes its existence."[7] About 5–6 million years ago profound changes of the human brain provoked the establishment of a new dimension of 'life': the noosphere shaped dynamically by humans combined with a vast increase of populations. Self-organization associates with a triadic concept:

(*1*.) the eïstheton as the perceptible dimension,
(*2*.) the noëton as the comprehensible dimension,
(*3*.) the ethiton as the affecting dimension.

These are presuppositions which lead to evolution and with the human evolution to culture which has organismic roots (Tembrock 2006b). The roots of culture we owe to the primates.

Quo vadis, Homo?

5 *Zeitschrift für Humanontogenetik* (1998–2006, Berlin: Logos, Bielefeld: Kleine); *human_ontogenetics. An International Journal of Interdisciplinary Developmental Research* (since 2007, Weinheim: Wiley-Blackwell).

6 Tembrock and Wessel 1998, p. 3.

7 Tembrock 1998a, p. 5.

Supplementary Figure Added by the Editors

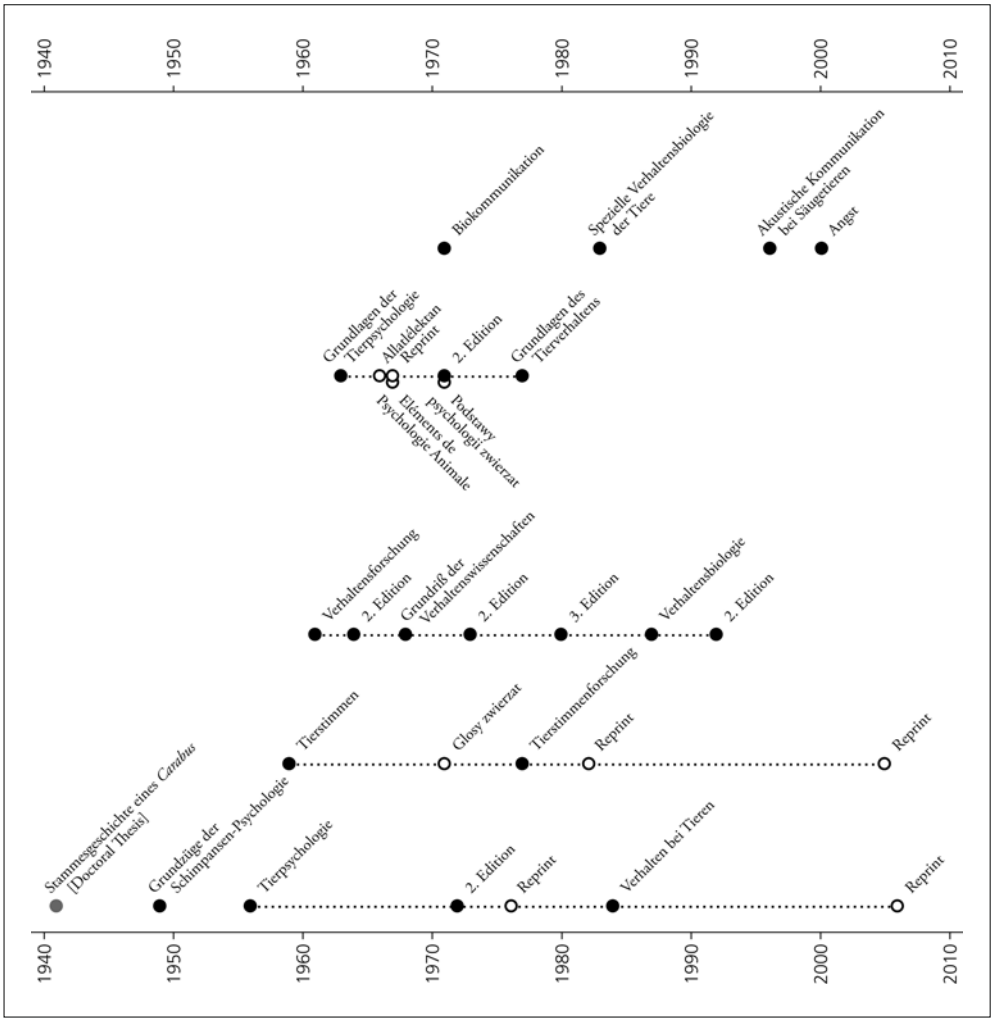


Fig. S1 Overview and 'evolution' of the books of Günter Tembrock

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Internetresources

Tierstimmenarchiv (*Animal Sound Archive*), Museum für Naturkunde – Leibniz Institute for Evolution and Biodiversity Research at the Humboldt University Berlin: www.tierstimmenarchiv.de

Note

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