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ON THE DESCRIPTIVE TERMINOLOGY OF THE INFORMATION TRANSFER BETWEEN ORGANISMS

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Information transfer implies two independent beings (a sender and a receiver) and two distinct, although closely tied levels of reality (the level of a message and the level of its production). In other words the „information transfer" is a multi-layer reality. The investigation of the „causal" mechanisms presupposes a proper description of the phenomenal effects. It is the phenomenal sphere of the directly observable events which provokes – in our mind – the questions driving the effort to explore the „mechanisms".

It is absolutely crucial, therefore, to approach the process of description with the sufficiently unbiased means. A premature narrowing on the descriptive level may fatally affect our „explanatory" ideas on the underlying mechanisms. For instance, in the realm of „information theories" there is a deeply rooted, but not too reliable conviction, that the descriptive means, used in the process of the construction and utilization of some technical devices, give us a fair chance to describe the „information transfer" within or between the living creatures.

> „... it is obvious that genetic information system as a general concept of many aspects is *not* isomorphous (or even analogous) to the electronic information system. Just as the latter deals only with signals and their accompanying noise, irrespective of their meaning, so should its genetic analog comprise only the mechanisms of replication, transcription and translation that operate on sequences of monomers irrespective of their biological meaning. However, the messages of interest in molecular biology are much more than just sequences of monomers. They contain all the biologically meaningful aspects of genetic information that represent the purposeful organization of living cells and organisms. As such, they should be correlated with their corresponding meaningful aspects of human information that represent knowledge, learning, memory and the like. Rational application of Shannon-Kolmogorov-Chaitin Information Theory to molecular biology must make these distinctions. [... Otherwise, the claim ...] that information theory can serve as the mathematical foundation of molecular biology is ill-conceived" (Lifson, 1994/ 373-374).

The practical meaning of the above quotation, which is primarily concerned with the proper description of the biomolecular phenomena, may be easily applied to the field of behavioral phenomena. The technical or formal (logico-mathematical) terminology of the „information theories" was shaped to describe a strictly limited kind of dynamism. To apply this selective framework to the evidently different kind of objects is like keeping a flower in a violin case. This obvious statement prompts us to a revision of the main linguistic framework, which is used today to present the data on the information transfer between the animals.

The ambiguity of the „information" concept.

Philosophical and biological text use the term „information" in the „active" or in the „passive" meaning. The „*active* information" term was used in the context of embryogenesis (developmental information) and in the context of cognition (psychological information). For instance, the relatively homogenous content of hen's egg is *shaped from within* (in-formed) during the 21 days of embryogenesis. Analogously, the concept of human anatomy is gradually shaped in the memory and thoughts of a student, during the first period of medical studies. It is „shaped" *within* one's mind, and by the inner effort of one's cognitive means.

These two *active* meanings of the term „in-formation" were a commonplace in the thomist philosophical school, but could hardly be found in the modern repertoire of philosophical or scientific concepts.

The term „information" is also used in four distinct, more *passive* meanings, referring to:

1. the *object's information*,
2. the actual *cognitive information* of a subject,
3. the stored, *memorized cognitive information* of a subject, and finally
4. the *symbolic information*.

Let us explain the above classification in some details.

Ad 1. *Object's information* is the concrete, actual inner „complexity" of an object (a geological formation, the Kodak camera, the Moon, a bacterium or a written text) under investigation. For instance the chemical structure of the ΦX 174 *Escherichia coli* phage, or the actual shape of the African continent constitutes the *object's information.* This „information" exists independently of the subject's cognitive efforts. Of course the regular crystals of NaCl have a quantitatively and qualitatively lesser informational content than a single human chromosome, or the whole frog's life cycle has a much more complex objective information than just its larval (tadpole) stage.

Ad 2. The *actual cognitive information* of a subject means this set of object's properties, qualities or other entitative characters with which a concrete subject has a direct cognitive contact in a concrete time and space. In other words that is the direct, actual *evidence*. One observes the clouds floating high in the sky, or a fly, trying to escape through the closed window. This evidence, or *actual information* may refer to animate or inanimate objects. It may also – of course – refer to the shape, color and dimension of symbols, the sequence of words, phrases and other linguistic media of communication.

Ad 3. The *stored cognitive information* refers to our concepts, i. e. the more or less fragmented elements of our cognitive experience with reality. The extent of

fragmentation and the way in which this information is stored, may vary from one subject to subject. This sort of information may come obsolete, and is usually updated by new and new cognitive efforts and by different attempts to overcome the piecemeal character of the direct, actual evidence.

Ad 4. Finally the *symbolic information* refers to individual symbols or their sets, which are arbitrarily tied with the pieces of the stored cognitive information, i. e. with our concepts. Arabic alphabet and arabic language symbols are different from the Hebrew, English or Latin ones, but they are – roughly speaking – commensurable in their capacity to *represent* the essentially inaccessible set of our concepts.

Anyone who takes a volume of British Encyclopedia and reads, for example, the essay on bacteria, has the direct evidence of the symbolic information of the latin alphabet and the English language. Supposing he knows this language, he can reach the ideas of the author of this article. He cannot, however, reach the „objective information" of the bacteria, as they exist independently of human mind. He would have to take a microscope and watch the bacteria swarming in a drop of water.

In our opinion, the modern technical and philosophical writings apply the word „information" indiscriminately, without proper and necessary distinctions. The essential gap between the sign-reality and the object-reality is muddled[1] . The technically feasible „information transfer" consists in the exchange of the sign-reality *(symbolic information),* while the true informational capacity of the signs remains mysterious. Sometimes the context gives the necessary hints to encipher the proper meaning of the given text. On the whole, however, the complexity of the problem does require a more complex and more clearly defined terminology. In our attempt to create a more convenient terminology we will analyze some instances of communication between organisms. We hope that the closer scrutiny of these dynamisms will lead us to the right descriptive conceptual pattern.

The right descriptive conceptual pattern. We are not concentrating here on the creation of a new set of symbols. We are just trying to conform our mental ideas (our concepts) to the kind of complexity proper to our observational objects. For instance, the idea of a „segment" was clearly acquired by the observation of some invertebrates, e.g. earthworms. Similarly the idea of a „vertebrate" is dependent upon the direct observation of once living but *postmortem* dissected objects. On the contrary the idea of a „plane" or a „rectangle", while descriptively useful in mineralogy, has a rather insignificant application in the description of the dynamisms of life.

Symbolic communication between insects

„/.../ the most aesthetically appealing (to us) visual communication system is that of luminous insects, particularly fireflies *(Lampyridae).* These produce light flashes that are species-specific mating „codes" [see Fig. 1]. [The] timing and pattern of flashes bring the sexes together; on warm summer evenings (in eastern North America), we see cruising males, each flashing species-specific code to which females respond. If she responds in the appropriate code, he orients toward its source.

[1] A message is a sign, or a series of signs, transmitted from a sign-producer, or source, to a sign-receiver, or destination. Any source and any destination is a living entity or the product of a living entity, such as a computer, a robot, automata in general, or a postulated supernatural being (see: Sebeok, 1989/ 86-95).

J.E. Lloyd /.../ recounts a remarkable case in which females of *Photuris*, a predaceous species, lure smaller males of *Photinus* to dinner by mimicking the flashes of the latter's code. Moreover, female *Photuris* mimic at least four smaller fireflies and thus can vary their menu." (Horn, 1978/235)[2].

Now, let us make explicit the absolutely necessary (indivisible) elements of this behavior (see Table I):

One has to emphasis, that the analytical step is just an approximation. For instance, the element (1) implies a really fine correlation between the activity of photophores (light producing organs) and the locomotory movements of the flying male. Otherwise the flashes would lack their repetitive and distinctive character.

On the other hand one has to notice a remarkable selectivity of the described behavior. It appears in a strictly restricted phase of firefly's life – during the mating period. The process is limited to night-time. Without those limitations the activity of the photophores would be a tremendous waste of energy[3]. In complete darkness the meeting of males and females would be impossible. The racial discrimination would also be unimaginable, as the flashing pattern seems to be a crucial element in the recognition of the different varieties (species) of insects[4].

Fig. 1. Different forms of light signals used by fireflies. (Modified after Dröscher 1987.)

[2] See also Keeton, 1980/514-515.

[3] „The light-producing organs /.../ in males of North American fireflies /.../ are composed of large cells, photocytes /.../ The photocytes contain quantities of the chemical luciferin /.../. Nerve impulses from the last two abdominal ganglia release an as yet unidentified chemical which stimulates the oxidation of luciferin, catalyzed by enzyme luciferase. The oxidation release light in a reaction that is very efficient in that almost no heat is generated". Horn, 1978/223. In *Pyrophorus* (Elateridae) firefly, up to 98% of the chemical energy in the photobiological process is converted into light, while in the ordinary bulb the conversion does not exceed 5% – see Grabda, 1989/444.

[4] „/.../ firefly flashes ordinarily have fairly uniform intensities, durations and delays, and spontaneous flashing (usually by males) is in a fixed, characteristic rhythm. /.../ Typical male-female dialog tends to be quite stereotyped in amazing timing – so much so that flashing characteristics have come to be accepted as an important, and sometimes essential, part of taxonomic descriptions" (Buck, 1988/268).

Table I. Information transfer between male and female firefly.

(1)	male	–	*produces* flash 1
(2)	female	–	*perceives* flash 1
(3)	female	–	*recognizes* flash 1
(4)	female	–	*turns* upside down
(5)	female	–	*produces* flash 2
(6)	male	–	*perceives* flash 2
(7)	male	–	*recognizes* flash 2
(8)	male	–	*moves* in the direction of the flash 2

The light signals exchanged between the fireflies should not be treated by a philosopher as a separate object of study. This exchange is conceptually inseparable from the life cycle of the insect. No competent observer should forget that this behavior is determined by the proper functioning of many different organs (respiratory, circulatory, locomotory ... etc.) and, above all, by the proper embryogenesis of these organs[5].

To sum up, the flashing behavior constitutes a fragment of the selective, successful, fast and economical mating in fireflies. This selectivity is obviously dependent upon the complex system of orientation in the environment, mainly that of visual orientation. This orientation has to be properly described before a search for its inner mechanisms can start.

How to describe the functioning of the visual system – a linguistic problem. Here we are facing again the problem of a proper conceptual framework. We may use the words „influences", „stimuli", „signals" or „signs" – this list is far from being complete. Each of these words has many different meanings. The usage of a wrong word (a wrong connotation) in the description of the firefly's behavior might ruin, or eliminate a crucial part of the empirical content of this phenomenon.

On the other hand we try to keep contact with current language, with the commonsense concepts. We hope to find the right descriptive wording not by introducing something new and uncommon, but to select and determine that part of common sense concepts which does justice to the essential characteristics of information transfer[6].

First we have, therefore, to reflect upon the meaning of the terms „influence" and „stimulus", because they are commonly used in literature and are among the first candidates of the descriptive set of concepts. To illustrate the problem we will discuss some elementary data of photobiology.

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[5] On the compound eye of fireflies and their unique ommatidium structure see e.g. Wolken, 1975/147-149, and for their lantern see e.g. Prosser, 1978/602-604; Wolken, 1975/266-267

[6] In the professional vocabularies, e.g. in the *Dictionary of Science and Technology* (Morris, 1992) many words used in the everyday common meaning have a „technical", more restricted meaning. Philosophers, however, too often disregard the need of a strictly defined linguistic framework, which may lead to misunderstanding or error.

Let us have a look at the Table II illustrating the empirical relation between the intensity of light and the activity of some living bodies.

Table II. Relation between intensity of illumination and the form of biological dynamism.

light intensity Wm^{-2}	a commonsense match	biological threshold of activity
10^{2}	sunny day	
10^{1}	cloudy weather	
10^{0}		blooming
10^{-1}	twilight	germination
10^{-2}		
10^{-3}	full moonlight	color vision in humans
10^{-4}		greening of plants
10^{-5}	weak moonlight	germ phototropism
10^{-6}		mushroom's photoptropism
10^{-7}		B/W vision in humans
10^{-8}		
10^{-9}	starlight	standstill of oat's
10^{-10}		germs

On the left side of Table II we can see the scale of the decreasing light intensity in terms of the energy fluency rate (or flux) – Watts per meter^{-2}. In the center some easily observable light sources of different intensity are indicated – to create a link between the abstract quantitative expressions and the phenomena of real world. On the right side the threshold level of some photobiological dynamisms is indicated.

There is no general relation between the intensity of non-biological sources of light and a photobiological dynamism. No mineral (astronomical) source of light is intrinsically determined to produce the illumination which would fit to a given form of photobiological process. In other words, there is no detectable, natural (physico-chemical) correlation between the intensity of sunlight, moonlight or starlight on one hand and a photobiological dynamism on the other. The intensity of energy flux from the astronomical light-sources varies independently of the requirements of living bodies. In addition, the different kinds of living bodies – different groups of them – have quite different photobiological needs and capacities.

In a weak moonlight (10^{-5} Wm^{-2}) – as we have seen on the table II – some plants move in the direction of the light source. When the moonlight is more intense (10^{-4} Wm^{-2}) the same plants may start the production of photosynthetic machinery (this machinery will then wait until the level of illumination further increases, to reach the *„threshold of utilization").* If the illumination increases beyond a certain, strictly determined limit (the „*threshold of a danger"*), the plant can apply specific protective mechanisms, to di-

minish the adverse influence of the too strong illumination[7]. The organism of the plant is obviously capable to distinguish between different levels of illumination.

The biological idea of a „threshold". This idea is rather complex and needs some explanation. It may refer to the acts of *monitoring, measuring, utilizing* or *avoiding* the energy of the surroundings.

I can *observe* the water in a river, I can *measure* (with a certain degree of precision) its changing flux and eventually I can *utilize* it with the aid of a water-mill, I can reduce the excess of the water flow reaching the water-mill.

Threshold of *monitoring*. The term *monitoring* refers to the detection, tracing, and observation of an object or a selected aspect of surroundings. Monitoring of light energy provides the organism with a certain orientation in the direction, intensity, or even color of light[8]. This process is selective, i.e. is relatively insensitive to other forms of energy, and usually has a limited range of direction (just a sector), intensity or color of light (just a range of wave length). For instance, a weak moonlight (10^{-5} Wm^{-2}) does not provide a seedling with the energy sufficient to drive photosynthesis. Yet, its direction may be detected and interpreted as a hint where to move in order to get a chance of better illumination. The „hint" means, of course, the result of monitoring.

Threshold of *utilization.* Photosynthesis and photophosphorylation are biological dynamisms which do not *monitor* the direction or intensity of light, but *utilize* its energy to drive some strictly determined chemical reactions. These mechanisms require a constant amount of energy per time unit – like a concrete water-mill utilizes a relatively constant quantity of the hydrodynamic energy of a brook. When the level of the energy supply falls below a certain threshold, the process comes to a stop.

The essential difference between monitoring and utilization is that the former runs on another source of energy while the second runs on the energy of the source itself. In other words the monitoring requires an external alimentation[9].

The subtle sensitivity of light receptors, for instance, depends on a complex dynamic pattern of biochemical reactions, driven by a constant supply of the ATP-molecules, which serve as the source of chemical energy. Because of this „external" alimentation – strictly coupled with the actual input of photons – even the physically minimal amounts of light (single photons) can be detected by some living cells.

Threshold of *escape*. If the intensity of the monitored energy exceeds a certain level, the organism may activate its means to reduce the possible adverse influence of this energy.

Threshold of *measurement*. Living organisms do not enjoy a constant input of the energy of light. The complex movements of the celestial bodies, together with the extre-

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[7] See: Koszteyn & Lenartowicz SJ, 1997/71-102

[8] „The fact that some unicellular organisms respond to illumination by accumulating either at the light or dark side of vessel in which they are contained, has been subject of scientific study for more than 150 years. The reason for this interest is, of course, the realization that such organisms contain a sensory system that enables them not only to perceive light, but apparently also to determine its direction" (Diehn, 1979/25).

[9] „The energy carried by a stimulus is usually much smaller than the energy utilized in the process of stimulus' reception." (Hadorn & Wehner, 1985/267). See also: Zurzycki & Michniewicz, 1985/642

mely complex temporal pattern of clouds result in the complex oscillations of the light energy fluency rate, as measured in a determinate point of space and time. It seems evident, that the perceptive capacities of living bodies are not capable to register the most minute changes in the above mentioned intensity of the energy flux.

Summing up, **a „threshold" (biological) means a kind of discontinuity of biological reactions to the essentially continuous fluctuation in the intensity of a specific external influence.**

The different patterns of dynamism in plants – evidently correlated with the fluctuations in the level of light flux – give us the following information: [– as we have seen in the Table II –]

1. the organism may undergo the *influence* of many environmental agents, such as, for instance, the inanimate sources of light energy, thermal energy, mechanical energy, electric, magnetic, cosmic ray's energy ... and so on. So far, as the organism remains passive in front of these influences, their effects are completely determined by the physical parameters of the organism's body, and the physical parameters of these factors.

For instance a lizard is passively heated by the sun rays. This process of heating is not essentially different from the heating of a rock. But unlike the rock, the lizard monitors the sun ray energy and actively moves from the shadow to the sunny patch.

2. the organism is capable of *monitoring* several different forms of energy,
3. the organism is capable of *detecting the differences* in the intensity of the monitored form of energy,
4. the organism is capable of *adapting* its own dynamism to the actual level of a given, monitored form of energy,
5. the organism is capable to *escape* from the dangerous or harmful environmental influences.

This means of course, that, for instance, an organism is not passive in respect to the illumination, but tends to detect the light, tends to detect the fluctuations of its intensity and tends to utilize this information for its own profit (escaping it, moving towards it or utilizing it)[10]. The word „tends" refers, for instance, to the process of production of photosensitive structures, to the process of the gradual adaptation of structures, the directional growth ... etc.

Anthropo-, bio-, and technomorphism in the description of the object

Two erroneous, misleading forms of „scientific" description of phenomena of life seem to dominate in modern biology. One might be labelled *fragmentarism*, and the second might be called *biomorphism*.

Fragmentarism. Biologist is confronted with an exceptionally complex pattern of structures and dynamisms. Mentally, he is able to detach any fragment of the object under observation from the rest of the pattern. He can, therefore, pluck out – in his mind – a single CO_2 molecule, and pretend that the complex process of respiration can be properly represented by the diffusion of this simple molecule. The mythical *self-replication* of the DNA, is the best known example of fragmentarism.

[10] See: Koszteyn & Lenartowicz SJ, 1997/71-102

The *fragmentarism* we criticize, should be carefully distinguished from the necessary analytical procedures used in biology. Analysis of a living cell reveals its inner complexity, and it has to be completed by the reconstructive stage of the description. The resulting complex idea of a cell cannot be considered as fragmentary. It is much more complete, than the initial, blurred, pre-analytical concept.

Fragmentarism substitutes *pars pro toto*. It consists in an excessive simplification. It creates an illusion of understanding[11].

Biomorphism. The biased, notoriously reductionist methodology of modern biology tries to see the principal causal mechanisms of life in the physico-chemical structure of biological surroundings, or some abstract and fragmentary aspects of life. This hidden option is manifested in the *biomorphism* and the technomorphism of some „scientific" descriptions of phenomena. Take for instance such a phrase:

„The light *prevents* etiolation, *influences* the germination of seeds and *induces* photoperiodic phenomena. The light *acts here as a source of information,* not energy – as in the photosynthesis. The *information is transferred* by means of specific photoreceptors. As a final result the plant inhibits the growth of its stem, speeds up the development of leaves, starts blooming ... etc. All *those changes are the result of the irradiation,* influencing the metabolic processes, the expression of genes [italics by JK/PL]"[12].

The above terminology seriously modifies the actual nature of the observable dynamism of life. It endows the inanimate forms of energy with some fictitious capacities, and – to say the least – creates a serious danger of conceptual chaos and misunderstanding. The words „information transfer", „to prevent", „source of information", „to inhibit", „to produce", „to control ..." used in reference to the astronomical sources of light have to be labeled a „biomorphism" or „technomorphism". The liberal use of this language reminds us the anthropomorphism of Plato's, who wrote: „ /.../ the sun is not only the author of visibility in all visible things, but of generation and nourishment and growth /.../" (*The Republic*, 509.b.2)[13].

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[11] „It is sometimes referred to as the fallacy of „nothing but". Of many examples of this undue simplification, we find all human cognitive activity reduced to sensation; life reduced to purely biochemical categories; Darwin's reduction of all man's higher powers and higher activities (e.g. choice and moral purpose) to quantitative differences from primate instinct; Marxist reduction of all motivation to the economic" (Wuellner SJ, 1966/262-263).

[12] We restrain from giving the source of this quotation. But this kind of language is quite common among biologists. Compare for instance Häder & Tevini (1987/XVI): „The morphology of an organism is *controlled* by light. /.../ Light *induces* leaf growth and *stimulates* chloroplast development /.../", or Haupt & Feinleib, 1979/4-5: „Whenever an external stimulus (e.g. light, gravity) *controls* a movement, the entire phenomenon can be described in terms of reaction chain containing three major 'links': Perception /.../ Transduction /.../ and Response". [italics by JK/PL]

[13] „/.../ stimulus may produce a single product which then initiates a process which was not occurring previously in the organism: for example, the production of chlorophyll from its precursor protochlorophyll. The quantum of light energy is utilized to convert a protochlorophyll molecule to a chlorophyll molecule, a product which was not present previously" (Shropshire, 1979/12). In the above quotation a *necessary condition* (light energy) was taken as the whole cause of chlorophyll production. In a similar vein one might claim that „coal produces the electricity in the power station".

If one would transfer this kind of terminological exaggeration to the world of technology we would have to agree that:

> ... the wind *prevents* or *provokes* the construction of windmills, *acts as a „source of information",* which is transferred by means of correctly constructed wings, and that all these changes – down to the production of flour – *are the result of the wind,* influencing the expression of the technical blueprints.

Anthropomorphism consists in the „assumption of human beings that their own characteristics are present in beings or facts widely different form themselves, more particularly in gods or in the forces of nature."(Stetson & Jastrow, 1901/55). Biomorphism consists in attributing some biological capacities to a purely mineral dynamism. Technomorphism consists in attributing some machine-like properties to a purely mineral dynamism. If a premature anthropomorphism is wrong, so is the premature bio- and technomorphism[14].

Influence vs stimulus

In our opinion it is counterproductive to use the words „influence" and „stimulus" as synonyms.

We propose to retain the word „influence" as a descriptive term used to denote the dynamism occurring in the mineral world – e.g. „the Sun influences the surface of the Earth, by its radiation and its gravitational field". It would sound ridiculous to hear that the Sun *stimulates* the tidal dynamism of oceans, or that the flow of the river *stimulates* the changes of the river bed.

A small portion of the current of air which moved a leaf on a tree, has no existence on its own, so to name it a „stimulus" constitutes a linguistic abuse. I can take away a bucket of water from a river, but it is not proper to think, that the river is a flow of water-buckets.

We propose to keep the word „stimulus" as a descriptive term, used to denote some specific dynamic processes observed in the sphere of biological or machine-like entities.

Let us give some details of the current and scientific usage of the word „stimulus". The first, necessary condition to recognize that „a stimulus" did occur is the so called „response" of the organism[15]. The idea of a „stimulus" is necessarily linked with a specific (not just abstract) kind of energy. Finally, no biologist talks about „stimuluses" if the organism under observation has no means to detect (perceive, monitor) this strictly determined kind of energy.

> *Mougeotia* plant monitors the intensity of sunlight. Sunlight acts in a nonselective way, *influencing* both *Mougeotia* plant and its environment as well. Sun does not *stimulates* anything – it just *influences* other bodies. When a certain threshold of intensity of illumination is overstepped, specific contractile fibers in the *Mougeotia* cell body slow-

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viously" (Shropshire, 1979/12). In the above quotation a *necessary condition* (light energy) was taken as the whole cause of chlorophyll production. In a similar vein one might claim that „coal produces the electricity in the power station".

[14] On some benefits of limited anthropomorphism in the description of animal behavior see for instance: Ristau, 1991/118-120.

[15] See for instance Shropshire, 1997/11

ly turn its chloroplast plate from perpendicular to the parallel position in respect to the direction of light-rays[16]. This demonstrates that *Mougeotia* not only monitors, but actually measures the intensity of light. One might say that monitoring is both qualitative and quantitative. Where is the „stimulus" in the above example? „Stimulus" originates within the body of *Mougeotia* on a certain threshold of light's intensity. This threshold is determined by the immanent need and capacities of this plant, and not by the sun-rays.

„Stimulus" means here an inner, physiological mechanism which links the monitoring, photosensitive device with the mechanical, contractile system of fibers. In biology this system is referred to as „transduction system".

In the light of the above discussion we cannot accept the terminology proposed by Haupt and Feinleib (1979/4-5).

The authors, in our opinion, commit the grave sin of biomorphism (see above). They wrote:

> „/.../ Whenever an external stimulus (e.g. light, gravity) controls a movement [of a plant] /.../ perception /.../ transduction /.../ and response /.../ takes place".

„Control" in the quoted sentence is a manifest example of biomorphism. In our view light or gravity *influences* a plant, but does not *control* it.

Shropshire (1979) following the Haupt's and Feinleib's terminology accepts the following sequence of events which occur when a plant is exposed to a „stimulus".

Stimulus → Perception → Transduction → Response

In our opinion this scheme is also wrong. The sequence of events which actually occur is this:

Influence → qualitative and quantitative monitoring → stimulus
(transduction) → response

The energy of the influencing body (sun-rays) is monitored, but not utilized to move the chloroplast. The act of light-perception is not a driving force for the translocation of the chloroplast. This driving force is provided by the contractile fibers. The activity of the contractile fiber system is *controlled* by the photomonitoring system. Now, the *control* involves a *stimulation* of the contractile system. Stimulation (transduction) links the monitoring system with the response system.

Influences	**Monitoring**	**Stimulus**	**Behavior**
heat	thermoreception	thermostimulus	a specific
impetus	mechanoreception	mechanostimulus	behavioral
light	photoreception	photostimulus	response

Influences can be undistinguishable, distinguishable, utilizable, dangerous, destructive. The threshold of distinguishability, utilizability or damagebility is determined by the inner properties of a given, concrete living body. For the sake of the descriptive precision the meaning of the word „stimulus" has to be contrasted with the meaning of the word „influence".

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[16] About Mougeotia chloroplast movement see e.g.: Alberts *et al*., 1989/1171-1172; Alberts *et al*., 1994/789; Britz, 1979/174-190; Hoppe *et al*., 1983/548-549; Kopcewicz *et al*., 1992/183-184; Kopcewicz & Lewak, 1998/264-265; Zurzycki & Michniewicz, 1985/370-379

Inanimate objects exert „influence". Biological objects may both „influence" and/or „stimulate". A carnivore dismembering its pray „influences" this dead body, but does not „stimulate" it. The distinction between the stimulus *sensu stricto* and *sensu strictissimo* is based on the distinction between the monitoring (process of orientation in a surroundings) and a behavioral answer to the environmental agents. Similarly there is a difference between *watching* and *catching* birds or butterflies.

If, however, someone says that the word „stimulus [means] any agent, act, or influence that *produces* functional or trophic reaction in a receptor or in an irritable tissue"[17] we have to protest and reject this statement as an example of an unjustified anthropomorphism, technomorphism or biomorphism (see above).

Entities are not „objects" if a „subject" is lacking. Water is not a „drink" if a living animal does not exist to drink it. „Stimulus" refers to a relation between the actual potentialities of a given living body and the parameters of the environmental inanimate agent. Apart from this relation the word „stimulus" has no definite meaning at all. „It has been suggested that a stimulus is better defined only in terms of its physical parameters"[18]. In our opinion this suggestion leads nowhere. Remove living beings and their needs, all the „stimuluses" loose their meaning.

> Suppose a radio set is tuned to a certain frequency of radio waves. Because of this restricted, selective tuning, only a strictly determined wave is a „stimulus" to this set. It is the process of tuning which determines the actual, concrete meaning of the word „stimulus". If, by chance, such a „stimulus" does appear within the range of the radio set, it is actively „received" by this set, and its „reception" starts a series of other dynamisms within this set (amplification, transformation, modulation etc.).

What does it mean? The process of stimulus reception is a biological activity *par excellence.* The technical illustrations and technical models of stimulus reception are all rooted in the activity of *Homo sapiens,* and cannot, therefore, be treated as examples of a purely physical dynamism[19].

On the ideas of „stimulus" and „signal"

Now we have to ponder for a while on the differences between the meaning of the word „stimulus" and the meaning of the word „signal". The word „stimulus" implies a selective relation between a given form of environmental energy on one hand and a perceptive capacity of a living being on the other. This however, has no definite reference to a specific point of space or a particular moment of time. The common sense meaning of the word „signal" implies the following relations:

1. signal is produced by a „sender" which is (no matter whether consciously or unconsciously) orientated in space and time to the receiver[20],

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[17] *Dorland's Illustrated Medical Dictionary,* 1974.

[18] Haupt & Feinleib, 1979/5.

[19] It seems that a hundred years ago the idea of a „stimulus" and the idea of „stimulation" was more distinctly separated from the idea of a purely physical „influence" than it is today. Cfr. Titchener E. B. (1902).

[20] For example „Alarm calling occurred significantly less when males [cocks] were alone than when accompanied by a female [hen] that was or was not the mate" (Marler & Karakashian, 1991/190).

2. the above selection is marked by a dynamism which perceptibly contrasts with its background,
3. this dynamism is perceptible to the *signal receiver*[21],
4. the perception of the dynamism is somehow correlated with a more or less strictly determined meaning – sort of a message[22],
5. the above meaning of the dynamism can somehow be grasped („understood") by the recipient[23],
6. the circumstances in which the „sender" emits its signal are evidently correlated with a strictly determined pattern of behavior in the recipient[24].

Signal clearly differs from *stimulus*. Signal is produced by a living organism, while

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[21] „It is necessary first of all to introduce and define the concept of valence. /.../ I call valent, or possessing valence, those objects, or characters of objects, and those events, in the perceptual world of an animal, in respect of which it shows behavior. „Valent" means, in effect, *perceived, attended to, responded to* [italicized by JK/PL], in the particular situation considered" (Russell, 1938/179).

In the context of signalization Wickler and Vane-Wright introduce the following terminology: (1) *model* – the thing (animate or inanimate) or function being imitated; (2) *mimic* – the imitating organism; and (3) *operator* (signal receiver) – the organism that is unable to discriminate effectively between model and mimic (see: Wiens, 1978/366). One has to keep in mind that the above described cases and forms of mimicry obviously tend to elicit a strictly determined kind of behavior in the receiver.

[22] „Orchid flowers may duplicate olfactory, visual, and tactile reproductive cues of the female insects. In the European and North African orchids of the genus *Ophrys*, /.../ male insects are attracted to the flowers even when they are hidden /.../ Thus scent is apparently the primary attractant, and visual orientation secondary. Finally, at least in some species of *Ophrys*, a series of tactile stimuli may complete the deception, guiding the male to the 'proper' location where contact with pollinium or stigma is assured" (Wiens, 1978/389).

„A comparison between the characters of the insects and the *Ophrys* flowers which act as sources of stimulation for the insect activity in question – attraction to and attempts at copulation – rather gives reason for the comprehensive conclusion that, *as regards habitus, the flowers (the labella) appeal to the real fundamental of the innate releasing mechanism of a widely definable insect type, whilst, as regards tactile stimulation ability and scent, they appeal to the releasing mechanism of certain types of aculeate Hymenoptera, and then, as regards olfactory stimulation, in a most specialized way*" (Kullenberg, 1961/297)

[23] „Instead of qualifying as valent such features and events as elicit response, we might call them significant or meaningful stimuli. But to this course there are two objections. First, the word stimulus is, strictly speaking, a physiological concept, and should accordingly be used only in connection with the physiological treatment of behavior, which I here reject; secondly, the word significant might be taken to imply that the animal is consciously aware of the significance or meaning of the object or event to which it responds, and this we are by no means entitled to assume without definite proof" (Russell, 1938/179-180).

[24] „We now know that tobacco, maize and cotton plants produce herbivore-specific chemical signals in response to herbivory and that the specialist parasitic wasp *C. nigriceps* can exploit such information-rich signals in locating hosts. Moreover, these wasps exhibit a flexible behavioral response to different signals produced by phylogenetically distant plant families" (De Moraes *et al*., 1998/570-573). See also Leutwyler, 1997/16.

stimulus is a form of an inanimate influence. Stimulus carries no „meaning", except its own, determinate physical character. Signal has a meaning, which is evidently different from its physical properties. Signal is subordinated to the complex time-space of a given life cycle. Stimulus is not subordinated to the above mentioned time-space. The so-called *internal stimuli* usually are in fact signals – with the exception of pathological situations. Inner signals help to maintain the orientation of the body-parts during their development and their function.

On the structure of biological signalization

To make our discussion more intelligible let us illustrate the signalization process with the dynamism of an alarm-clock. An alarm-clock has to be put in a proper place (e. g. in the bedroom) and set up for a required time (e. g. 7.00 am). Its signal has no inherent, determined meaning. It may mean „wake up", or „call XY", or „take some medicine". There is no natural, physico-chemical link between the signal's dynamics (alarm ringing) and its actual meaning. Biological signals, however, are selectively followed by a determined pattern of behavior of a specific receiver. It is relatively easy, therefore, to detect the actual link between a given signal and its particular meaning. Hormones, products of the homeobox genes, biochemical address labels, pheromones, specific alarm-calls of birds and other animals are examples of typical signals. Hormones, for instance, do not shape the wings or legs in a developing body of an insect's pupa, but merely determine the region and time of this activity.

To grasp the full meaning of biological signals one has to consider them both from the position of the sender and the receiver.

Sender's „point of view".

1. There is an obvious correlation between the physiological state of the sender and the emission of a particular signal,
2. There is also an obvious correlation between the actual state of the surroundings and the emission of a particular signal,
3. A signal is a short lasting, dynamic phenomenon, contrasting with the actual background of the surroundings (e.g. bright flashes in darkness, or sharp shrieks in a monotonous noise). This means that the sender possesses the ability to evaluate the contrast between its own signal and its background.
4. There is a non random correlation between the physico-chemical nature of the signal and the perceptive capacities of its receiver.
5. Signal is obviously correlated with a specific behavior of the receiver.

Receiver's „point of view". Receiver has to gain different forms of orientation:

1. there is the nonrandom correlation between the physiological state of the receiver and its reaction to the signal, that means that the receiver somehow monitors its own physiological state,
2. the receiver has to make a discrimination between the „noise" and the signal,
3. it has to correlate the physical properties of a given signal with a particular kind of its own behavior – it has to „grasp" the meaning of the signal,
4. it has to find the proper space coordinates of its behavior (e. g. move in the right direction).

The „orientation" – as we have seen – means a non random correlation, dependent on

perception. We have tried to demonstrate the existence of different, and irreducible forms of orientation which seem to underlie the process of signalling between two biological entities. However, we are not concerned – at the moment – whether these forms of orientation are inborn, gained by experience, learning or training ... etc. We also leave aside the possible role of the DNA, of the central nervous system, and the problem of the sense organs. A deeper analysis of the underlying mechanisms is certainly possible and needed, but the results of further investigations cannot disprove or invalidate the correlations we just described.

When we compare the orientation involved in the process of sending a signal with the orientation involved in answering it we can conclude that the orientation of the sender is more complete and more embracing than the orientation of the receiver. In other words, the sender dominates – in a way – the receiver and „manipulates" it. Signalling – in its simplest form – is a non-symmetrical relation, and has to be distinguished from a dialogue.

Turning back to fireflies and their behavior we may notice that the exchange of signals between the male and female is a sort of a dialogue – which is most manifest in the exchange of signals between the credulous *Photinus* male and the carnivorous *Photuris* female.

Orientation transfer in honeybees.

We intend now to reflect on some evident phenomena, which, according to common sense, are strikingly close to human forms of orientation transfer.

„The work of Karl von Frisch of the University of Munich, Germany, on the language of bees is a biological classic. Von Frisch had long been interested in the ability of bees to distinguish between different colors and scents. In the course of his experiments, he would set up in the vicinity of a hive a table with sheets of paper on which he had smeared honey. He would then have to wait – sometimes for several hours – for the bees to find the honey. He noticed that when one bee finally discovered the feeding place, many others appeared at the table within a short time. It seemed likely that the first bee had somehow informed the others of the existence of the new feeding place" (Keaton, 1980/518).

[waggle dance] „A 'scout' bee that has located a new food source (newly bloomed flowers – or the ethologist's bee-feeding tray) returns to the hive and performs a figure-eight dance on the vertical comb inside during which she waggles her abdomen while walking upward."

[contact with other bees] „Because the bees are crowded together on the comb, nearby bees can feel the direction of the dance".

[an up-dated relation between the apparent position of the sun and the direction of the axis of the waggle dance] „Von Frisch /.../ demonstrated that the departure from vertical of the angle of the dance is equal to the angle of the departure of the food source from the sun and that the length of time spent per waggle-walk is proportional to the distance of the food source. Most remarkable is the fact that the bee may do a marathon dance for over three hours on the comb /.../, during which she compensates for the apparent movement of the sun through the sky by changing the waggle angle on the comb. The adjustment is done in the total darkness of the hive, without a peek at the sky; it is probably a function of the bee's internal clock and its conditioning to the movement of the sun".

[selective flight of other bees towards the discovered source of food] „Hive bees, perceiving duration and direction of the dance, leave the hive at the appropriate angle and fly the correct distance directly (more or less) to the food source!"

[odor as one of the directive phenomena] „Source odors on the dancer's body apparently are of lesser importance to other bees' response to the dance, though Gold /.../ varied the concentration of food odors and discovered that bees preferentially gathered at the stronger odor source."

[the decisive role of astronavigation] „He [i.e., Gold – JK/PL] demonstrated the importance of tactile communication by covering ocelli of dancing scouts in outdoor swarms. Unable to correctly determine the sun's position, blinded scouts „lied" about the location of food, and workers predictably flew to the wrong place." (Horn, 1978/237)[25] *[The numbering and italicized titles in this quotation are introduced by JK/PL]*.

After an encounter with a „dancing scout" a „worker bee" leaves its hive and flies directly to the food source „discovered" by the „scout". So it is obvious that the „worker" did not discover the source by its own activity but somehow utilizes the orientation communicated by the „dancing scout". What we are concerned with here is the evident transfer of orientation from a direct observer, via more or less formalized signals or signs, to an uninformed receiver.

In order to eliminate possible misunderstanding, we have to distinguish carefully between the transfer of different kinds of orientation:

(a) **Transfer of the orientation as regards the direction of the food source** – „the departure from vertical of the angle of the dance is equal to the angle of the departure of the food source from the sun". In other words „the direction of the food is *encoded* [italicized by JK/PL] in the angle of the waggle run" (Gold & Towne, 1987/318). The direction hive/sun is replaced by the direction down/up (Fig. 2 and 3)[26]. Experiments with a mechanical model bee fully confirmed the above described pattern of behavior (Michelsen *et al*. 1992/148).

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[25] For a more detailed description of honeybees communication including several components of the dance (omitted in this paper) see original papers of K. Frisch, and e.g. Banaszak, 1993/118-119; Barrington, 1972/ 462; Chalifman, 1968/74-81; Frings & Frings, 1968/97-98; Gold & Towne, 1987/ 317-338; Hart, 1996/26-29; Kirchner & Towne, 1994/54-61; Michelsen, 1996/1600; Michelsen *et al*., 1992/143-150; Szafer, 1969/159-190; Wilson, 1979/338-347

[26] „That honeybees dancing the waggle dance in a dark hive can communicate directions in terms of the sun's position means that they must be able to compensate for the apparent motion of the sun across the sky during the course of a day. If they continued to orient their dance to convey the location of a food source relative to the position of the sun as they last saw it, they would soon be giving the other bees erroneous information and these would depart in a wrong direction. This does not happen. The dancer slowly shifts the orientation of her dance relative to gravity, so that she is always indicating the direction of the food in terms of the position of the sun at that moment. To make such adjustments, she must have an accurate internal sense of time, a „biological clock". She must also somehow be programmed to shift her bearing at roughly 15 degrees per hour, which is the average rate of change in the sun's azimuth (direction from the observer) during the day" (Keaton, 1980/521). See also: Barrington, 1972/ 462; Frings & Frings, 1968/97-98; Szafer, 1969/190.

(b) **Transfer of the orientation as regards the distance of the food source** – „Distance is also encoded /.../ by run duration, the number of waggles, the number of sound bursts and the duration of sound production all correlate well with distance" (Gold & Towne, 1987/318).

(c) **Transfer of orientation as regards some physical properties of food** – „Von Frisch did find, /.../ that if each of the dishes of sugar water was scented with a different flower, the other bees came in significantly greater numbers to the dish that the dancer had visited. He showed that these bees determined what scent to search for in two ways: They smelled the body of the dancer by holding their antennae near her, and they detected the odor in the droplets of material she fed to them" (Keaton, 1980/519).

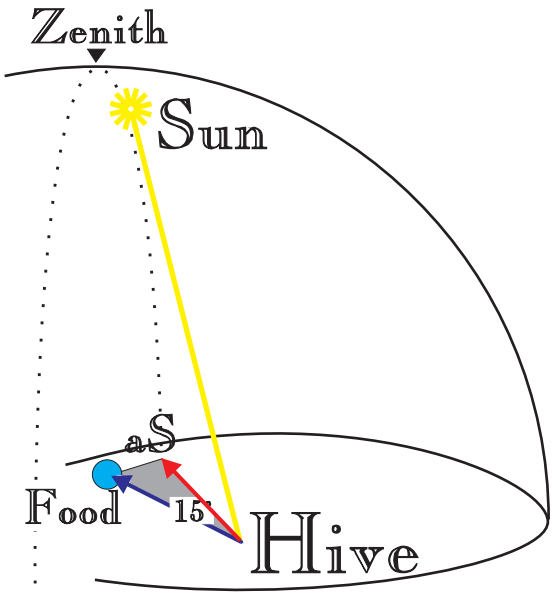

Fig. 2. The angle between Sun's azimuth (aS), the hive and the discovered source of food.

Comparing the above forms of the orientation transfer, we may notice that the last one form *is not* encoded – in the common sense meaning of this word. The bees which observe the waggle dance of the „scout" have to tie – somehow – its odor with the odor of the food they are looking for. But the „object" is not *substituted* by another kind of phenomenon. In the first two forms of transfer, however, we had to do with a *replacement* of spatial orientation through the means of phenomena which differ from the outdoor reality.

In order to describe more adequately the above mentioned forms of orientation transfer we propose the following terminological distinctions between:

A. a particular *operative, causal dynamism* (e. g. different patterns of locomotion, nest-building behavior, aggressive or protective behavior, communication behavior), and

B. a *cognitive, acausal dynamism* which supplies this behavior with a proper orientation in

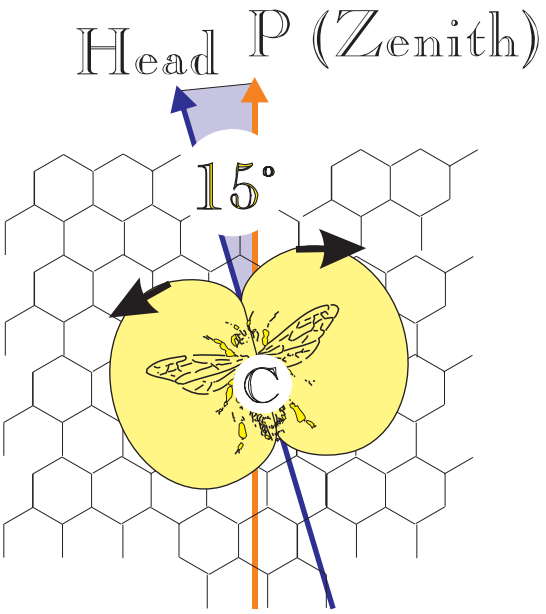

Fig. 3. The angle between zenith (P), center of the bee's body (C) and its head.

the entitative context. This latter dynamism should be further divided into

B1. a *direct orientation,* or auto-orientation (e. g. a „scout", an individual which noticed a danger and produces the warning signals) and

B2. an *indirect orientation* transferred from the direct observer by means of signs or signals.

According to these distinctions a specific type of behavior may be *properly or wrongly oriented.* Deception produces wrongly oriented behavior[27].

A necessary distinction between the „hardware", „software" and the „input" information. All the animals we discussed above, were equipped with properly shaped organs (tools – „hardware"), properly developed instinctive fixed patterns of dynamism (behavioral capacities – „software") and with the means of orientation. The latter in turn must be subdivided into the *observation* of their surroundings (external observation – „external input") or their own corporeal sphere (inner observation – e.g. sense of hunger, of thirst, pain etc. – „internal input")[28].

After these terminological remarks let us concentrate on the *indirect orientation* i.e. on the *transfer of orientation*.

[27] On deception see for instance Burghardt, 1991/53-90; Ristau, 1991/91-126; Cheney & Seyfarth, 1991/127-151; Benson, Brown & Gilbert, 1975/ 671; Gilbert, 1982/102-107B; Häder & Tevini, 1987/94; Kullenberg, 1961; Wiens, 1978/365-403; Lloyd, 1981/110-117; De Moraes *et al.*, 1998/570-573; Wiens, 1978/365-403.

[28] In modern biology there is a tendency to reduce all the behavior to the hardware (organic structures), and to reduce the orientation (external input) to the behavioral, inborn patterns.

Indirect orientation in surroundings

Modern biologists do not shrink from using the word „coding" in the description of biological phenomena. This is abundantly documented in the field of molecular biology, and it can easily be noticed in research on the communication between social insects. To denote the phenomenon of indirect orientation the word „coding" is commonly used. What does „the direction of the food is *encoded* by the angle of the waggle run" mean?

Horizontal „waggle-dance". To understand the descriptive sense of „coding" we have first to distinguish a „waggle-dance" performed on a horizontal plane outside the hive, from the vertical waggle dance performed in the darkness of the hive. In the first case the so called „straight run" (see Fig. 3) *directly indicates* the direction towards the discovered source of food – on the condition that the head of the „scout" is treated by other bees as an arrowhead, a finger-post. We will concentrate on the vertical waggle-dance, because it provides us with a much clearer example of the indirect orientation in surroundings[29].

Vertical „waggle-dance". The manifest „coding" is observed when the „scout" performs its waggle dance on a vertical plane of comb in the dark space of hive (see Fig. 3). Why we call it „coding"? Let us reflect on the main stages of this dynamism.

1. The „scout" *searches* for a new source of food. This search is provoked by an inner, inborn, „instinctive", selective tendency. This tendency is evidently successful, and this success depends on locomotion and the cognitive capacities of the „scout".
2. The „scout" f*inds* (recognizes) a new source of food. The recognition of the food is possible because of an inner, inborn, „instinctive", *estimative* capacity.

   Food means a determinate, physico-chemical substance, not just a set of accidental appearences, which may be deceptive. Therefore, a „scout" must possess sufficient cognitive means to find the *ontological truth* of food (a „true" food)[30]. It can also disregard secondary properties of food, such as a specific, or unusual odor, intensity of the nutritive value, or its actual color.
3. The „scout" *observes* and *remembers* the direction the source of food and the hive.

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[29] Quite deliberately we are selecting the most convincing empirical evidence, before we attempt a discussion of less evident or controversial examples.

[30] In thomist terminology *logical truth* means a right orientation in the properties of a given object of observation (a bee – for instance – is attracted to a cup with painted flowers but after inspection leaves this cup to continue the search for real food). This means that the bee did succeed in identifying various properties belonging to the cup, but was not satisfied by its search.

The *ontological truth* means not only a right orientation in the external, sense properties of an observed object, but a recognition of the more essential qualities of this object and previous expectation – be it inborn, subconscious, instinctive ... or else. In this sense, an experienced person can decide whether a mushroom is edible or not. A statement „this is an edible mushroom" informs us about the *ontological truth* of this mushroom, while the most complete description of it informs us of its *logical truth*.

Ontological truth cannot be gained without a capacity to grasp logical truth – but not *vice versa.* In the case of deception, the logical truth is gained, but the ontological truth is missing.

4. The „scout" *observes* and *remembers* the angle between the direction Hive - azimuth of the Sun (aS) and the direction Hive-Food (Fig. 2).
5. The „scout" performs its waggling dance, indicating the value of the angle without, however, directly indicating to them the actual direction Hive-Food or Hive-aS (Fig. 2).
6. Indirectly, however, the „scout" does indicate the actual direction Hive-aS. This indirect indication is an *encoded* indication. The direction opposite to the direction of the gravitational force serves as an indicator of the Hive-aS direction.

   Because of the lack of space we leave aside the analysis and the discussion of the encoded indicators of the distance H-F.

   To retrieve the orientation brought and encoded by the „scout" other bees have to:
7. faithfully register the activity of the dancing „scout" – during a single cycle of „waggle dance" the direction C-Head constantly changes (Fig. 3), so – to discover the encoded element of the dance – one has to concentrate its attention on the „straight run",
8. measure the angle of this dance,
9. transfer the angle from the perpendicular plane to the horizontal plane,
10. transfer the arrow P in the arrow aS
11. measure the angle FHaS
12. take the right direction or fly towards the source.

The essence of Frische's discovery consists in demonstrating that the value of the angle Head-C-P equals the value of the angle Food-Hive-aS[31].

Among ethologists there is no doubt, that a bee *indicates* to another bee *its own orientation* about a newly discovered source of food.

Non-phenomenal status of orientation[32]**.** Orientation can be considered as an *activity* (subjective orientation, an active capacity and tendency to be oriented) or as a *result* of this activity (entitative orientation, or actual orientation in a concrete surrounding): e.g. a dove has an orientation sufficient to find its nest, a dozen miles away. Both subjective and objective orientation are internal, invisible, non-phenomenal. Neither in bees, nor in humans was a specific orientation ever observed as a phenomenon. We can speculate or judge about „orientation" on the basis of phenomena (behavioral phenomena, for instance) but we never have detected the „orientation" directly, by our senses.

Mental experiment on the recognition of orientation by light. To illustrate our meaning of the word „orientation" let us consider the following situation. A number of phenomenal bodies are enclosed in a container which has just one, narrow entrance, the Gate (see Fig. 4). Both inside and outside the container there is complete darkness.

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[31] See Gold & Towne, 1987/320; Keaton, 1980/521; Michelsen *et al*., 1992/143; Schafer, 1969/161.

[32] We have to use the word „non-phenomenal", to stress the obvious difference between the sensitive properties of an object and nonsensitive content of orientation. We cannot identify a concrete direction or distance with a physiological dynamism of neural centres. We restrain, however, from any entitative hypothesis concerning this „non-phenomenal" but absolutely real aspect of orientation.

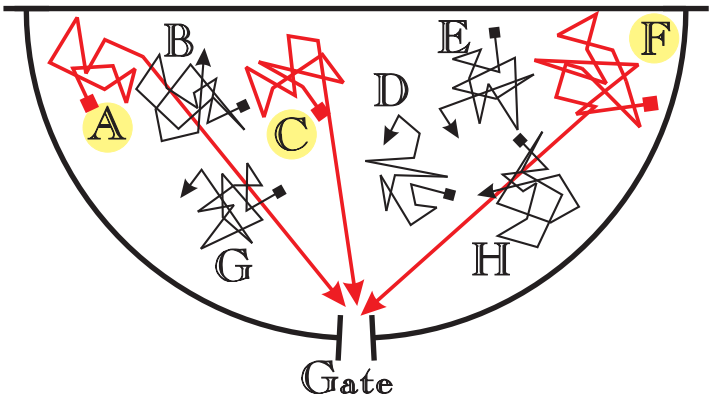

Fig. 4. Mental experiment on spatial orientation.

The bodies A, B, C, D, E. F are spontaneously moving at a random walk. In the moment *t1* a weak, uniform diffused light is switched on. The bodies B, D and E move in essentially the same, random way, while the bodies A, D and F quickly move in a straight line towards the entrance. Judging by the behavior of the bodies B, D, E one can say that these bodies do not react to the illumination. Judging by the behavior of the bodies A, C, and F one can say that these bodies not only (1) react to the illumination, but (2) achieve an *orientation* towards the position of the entrance, and (3) tend to escape from the container[33].

Phenomenal aspect of indication. Indication necessarily refers to orientation. But while the orientation is – as we have said – purely internal and in this sense absolutely non-phenomenal, the indication has both a phenomenal and a non-phenomenal aspect. It would be absurd to talk about a mental indicator, without the behavioral activity of the subject (see Fig.5).

***Physical* and *indicative* links.** One has carefully to distinguish between a crater in the ground (which is just a phenomenon) and orientation that this crater is linked with the fall of a meteorite – an event which happened millions of years ago. A crater as such, *indicates nothing* because indication is a subjective activity. When one discovers a link between a meteorite and a crater one discovers a *physical link* i.e. a causal relation. The crater, from this moment on, becomes a natural indicator of a meteorite impact, but it does not mean that this *indicative* link can be identified with a *physical* link of a causal relation. *Between the waggle-dance and the localization of food there is an indicative link. A spatial relation between the hive, food and sun is a purely physical relation, not an indicative relation.* The „scout" acquires an orientation concerning this physical relation and this enables it to create the indicative „structure" of the waggle-dance together with its referent.

Indicator is a complex reality. Every indicator consists of its phenomenal aspect (static or dynamic) and its orientational aspect which is invisible – non phenomenal. The two aspects can be tied, or linked together in different ways (see Table III).

[33] Compare the anecdote on the sitting room, flies and the housemaid by F. Wood Jones, 1961, p. 44. and the Buder's experiment (1919) on the orientation of flagellates in a converging and diverging beam (see Häder and Tevini, 1987/250).

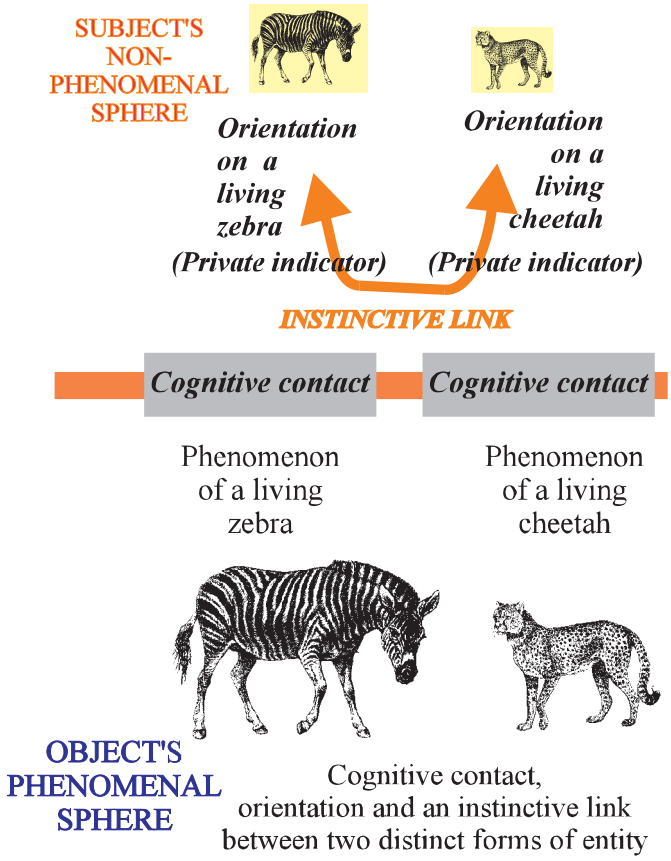

Fig. 5. Instinctive, non-phenomenal link.

Subject. Both orientation and indication are activities proper to a living being, endowed with cognitive and behavioral capacities. Without cognitive and behavioral capacities there is no sense in talking about orientation or indication.

True and quasi indicators. In the process of *orientation transfer* we have to distinguish between true indicators – *direct* or *indirect* and quasi indicators – e. g. *physical* and *nominal* relations.

Physical relation may be spatial, temporal or causal (e.g. closeness, immediacy, effect). *A parte rei*, i. e. prescinding from a possible knowledge, these relations indicate nothing. They just exist. The fact of indication originates because of a cognitive activity which has discovered an objective, subject independent relation between – for instance – a particular cause and its effect (crater and meteorite) or between an earlier and a later event.

Nominal relation is a sort of arbitrarily created link between two phenomena, e. g. two different marks, two different words, more generally between two different symbols.

A list of ***nominal*** relations (in alphabetical order) can be found in dictionaries. E. g. le cheval = the horse.

Why we refuse to accept physical or nominal relations as true indicators? The reason is, that neither physical, nor nominal relation involves an orientation in the surrounding[34]. In both cases no orientation transfer occurs.

***Direct* indicator** means that a subject is induced to gain an orientation of an object selected by another subject (the informer).

For instance, one can put a mouse in a black funnel, and to put the Moon at the entrance to it. The mouse will have no choice but to observe the Moon. This object was selected by the „informer".

The „scout" dancing on the comb, stops for a while to treat the attending foragers with samples of the discovered food. This gesture, according to biologists, is not just an act of feeding hungry friends, but an act of direct indication, referring to the properties of the discovered source of food[35]. The workers recruited by the dance will recognize the food source by olfactory cues picked up earlier by antennation of the dancing worker in the hive. The olfactory cue is a good example of a direct indicator.

***Indirect* indicator.** Foragers observing the „waggle dance" of the „scout" somehow gain a accurate orientation as to the direction and the distance of food. In the „waggle dance" one cannot *directly* know this direction and this distance. Foragers, therefore, have to:

(1) *translate* the vertical direction upwards into the horizontal direction from the hive entrance towards the sun and

(2) *translate* the head direction of the straight run of the dance into the direction from the hive entrance towards the food.

Without these translations the forager will not be able to fly to the food source at the angle indicated by the „dancer".

Next, the bee-foragers have to translate the frequency of the dance rounds into the proper distance to the food.

This complex translation is not based upon a stable pattern of physico-chemical dynamisms (physical laws) occurring in the inanimate world. The link between the frequency of the waggle-dance, for instance, and the distance to the food is *„conventional"*.

The problem of „convention" is crucial. In an attempt to elucidate it let us reflect for a while on the idea of an indicator.

The phenomenal aspect of any *indicator* (I) has to be distinguished from the phenomenal aspect of the *indicated* object, quality, or quantity (O). Next, a non-phenomenal, inner, subjective link (L) between the given I and its O has to be recognized. If there is no such link, no indication occurs.

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[34] See parable on the Chinese room by Searle, 1980/ 417-458

[35] Many flowering plants produce lines or dots (honey guides, nectar guides) that direct a pollinating insect to the nectaries. In some cases only an UV-sensitive insect can recognize those guiding lines which remain invisible to other foragers. See Harborne, 1997/71-74;Schafer, 169/44-45; Tootill, 1984/180. There is a family of birds (Indicatoridae). Their common name refers to their habit of guiding selected kinds of animals to bee nests, where they feed on the beeswax left by the animals that have plundered the nest. (Allaby, 1996/ 236).

All these three elements (I,L,O) can be either *natural* (N) or *arbitrary* (A). To illustrate our understanding of these two words, we have prepared the Table III.

It is important to stress that the above table refers to *indicative links* and not to *physical links.* For instance example 7 refers to our knowledge of a natural link (N) between the explosion of such an unnatural (A) object as an artillery missile and a given shell-pit (N).

Table III. Indirect indicators (**I**ndicator, **L**ink[=], **O**bject, **A**rbitrary, **N**atural).

	I–L–O	**Examples**
1	**A**–A–A	$\sqrt{}$ = „extraction of a root"
2	**A**–A–N	„horse" = large, solid-hoofed, herbivorous, domesticated quadruped used for riding
3	**N**–A–A	sunrise = summon to prayer
4	**N**–A–N	„morning spider" = „a misadventure in the afternoon"
5	**A**–N–A	a pilot signal = switch a channel on TV
6	**A**–N–N	four-bladed fan = air flow
7	**N**–N–A	shell-pit = explosion of an artillery missile
8	**N**–N–N	hen's egg = hen; atom = proton

Cognitive versus causal relation. In our opinion the first four examples refer to „symbolic" indication, while the last four examples refer to the natural phenomena which became indicators because of the discovery of a natural (cause/effect) relation between the I and O.

From the epistemological point of view it seems that every one of the above eight ILO relations is reversible, while from the entitative point of view the last four cases (5-8) are irreversible. For instance, airflow cannot produce the movement of an electric fan in the same sense in which the movement of a fan produces airflow. Analogically a shell-pit cannot produce an explosion. In other words, the last four ILO relations are determined by the inner, entitative links between the I and O, while in the first four relations the link has nothing to do with the inner properties of I and O.

An accurate description of signaling between fireflies and orientation transfer between bees must, therefore, rely on indirect and arbitrary indicators. This kind of indication we use to call a *symbolic* indication.

Ethologists confronted with the communication transfer between bees don't hesitate to use the terms „language" or „dance language", „symbolic communication" and even „communication of thoughts"[36]. In our opinion the common sense concept of „in-

[36] „The adaptive value of the dance language – and it is reasonable to call it a language since it refers to things distant in space and time by means of arbitrary conventions („up equals the sun's azimuth" and „one waggle equals 35 m.") – seems clear; it allows bees to share information for the rapid and efficient exploitation of rich, widely distributed, unpredictable, short-lived patches of flowers" (Gold &, Towne, 1987/ 320). „The symbolic communication used by honeybees to inform their sisters about the direction, distance, and desirability of various things suggests that even social insects may experience and communicate simple thoughts" (Griffin, 1991/ 15-16). See also Ristau, 1991/298-299.

dication" is sufficiently rich to represent the essence of communication transfer between biological beings. We have however to continue our analysis a step further. The „term" constitutes the basic unit of the orientation transfer[37].

The concept of a „term". „Term" is the basic unit of the process of indication. We decided to use „term" as the label for the first two kinds of tripartite relations shown in the Table III. Guided by our Principle of Cognitive Subordination (see above) and the long tradition of Aristotelian and Thomist philosophy we think it convenient to distinguish the following elements of the *term*:

1. a *„mark"*, i.e. a sensible, but arbitrary, or conventional, artificial reality
2. a *referent*, i.e. something *indicated* by the „mark" because of
3. *a link* between them (see Fig. 6).

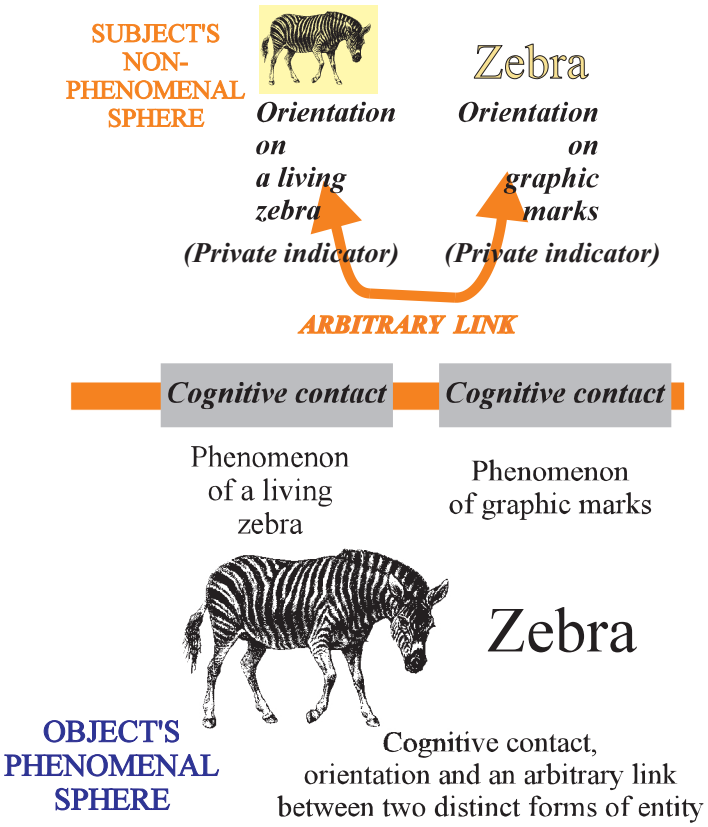

Fig. 6. Symbolic (arbitrary), non-phenomenal link.

[37] We are conscious that this approach contradicts Frege's thesis on the elementary character of a sentence. See for instance Blackburn (1994) on „reference", and Church (1942) on „term".

Perfect *mark* or *symbol* (see Scheme I). The „mark" (symbolon) has to possess some evident, sensible traits of arbitrariness, convention, and artificiality[38]. Otherwise it cannot serve as an element of a *term* in the just described sense (clouds, waves, mountain ridges are not used as symbols). A *perfect* symbol (or mark) therefore, is easily distinguishable from any natural, spontaneous reality. In this sense pictograms, photos, onomatopeia, snow-tracks, symptoms or causal effects are not *perfect symbols.*

Scheme I. Different forms of indicators.

the word „horse"	pictogram of the horse	skull of a fossil horse
Perfect symbol	Imperfect symbol	Natural indicator

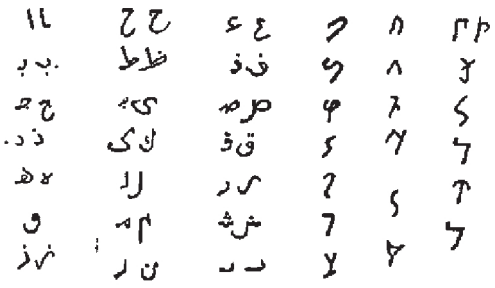

Fig. 7. Perfect symbols (marks). Arabic and Kharoshti characters.

In other words a *perfect symbol* is absolutely indifferent to every possible kind of link. The perfect symbol does not fit better or worse to any imaginable referent. Watching a symbol one is absolutely incapable of guessing – from its form alone – the possible referent. In this sense the idea of a *symbol* is contrary to the idea of a *natural indicator*. It serves as an indicator on the condition that it is incorporated within an arbitrary, conventional, artificial coding system (see Fig. 7).

Consequently, a *referent* of a symbol (mark) within a concrete *term* can be *anything*. A term may refer to an animate or inanimate entity, it may refer to an abstract aspect of it, to a part or an ensemble of artificial or natural beings.

Perfect *referent* (Scheme II). Perfect referent means a faithful – but not necessarily complete – orientation in the entitative sphere of a being – be it mental, material or mixed.

Here we can see the crucial difference between a direct indication – where the referent can be an external, subject independent reality, and the indirect indication where the referent means an orientation, subject-dependent reality.

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[38] Arbitrariness, „artificiality" in this case refers to the *origin* of a given „mark". In the analysis of a given „mark" one has to distinguish between its *material* and its *form*. If there is no regular pattern in this form, one cannot judge the origin of it. If, however, a regular pattern is manifest in the form, one has to check if it originates from the properties of the material (as, for instance in the crystal structure of some minerals) or is independent of those properties. In the last case, one has to evaluate the level of selectivity of this regular pattern. If this level is low, one can presume that the „pattern" by sheer chance originated the influence of some non-selective dynamism. If, however, the level of selectivity is high, one is forced to postulate a proportionately selective, external agency. To measure selectivity one has to evaluate the inner complexity of its pattern and its repetitivity (see: Lenartowicz, 1986/52-64; 263-276).

Scheme II. Different forms of referent.

Full orientation	Fragmentary orientation	Deception
Perfect referent	Imperfect referent	???

If the cognition of the referent (orientation in properties of the referent) is invalid, than the term (transfer of orientation) leads to deception.

Perfect *link.* (Scheme III). We decided to restrict the concept of the perfect link between two distinct phenomena to this one which is determined by the inner, essential properties of those phenomena.

Scheme III. Different forms of a „link".

„natural" „subnatural" necessary	accidental common average statistical	conventional odd unnatural accidental
Perfect link	Imperfect link	Arbitrary link

The arbitrariness of the *link* between the „mark" and „referent" means that an *external entity* has to intervene to create this link[39] . The four last examples (5-8) in the Table III do not require any such intervening entity, because one member of such a relation naturally[40], intrinsically creates such a link with the second member of this relation. This, however, does not solve a possible problem of the origin of these members.

The *natural* link within an indicator (a term) is invisible (non phenomenal) but it is physically discoverable. The *arbitrary* link within an indicator is not only invisible, but physically undiscoverable. It has to be *indicated* by a living body[41].

The number of instances in which a biologist is confronted with true indirect indicators is breathtaking. Many anatomical indirect indicators are well known, but even on the biochemical level the indirect indication is commonplace. The aminoacid and stop codons in the genetic messages of the DNA molecule, the promoter sequences recognized by sigma subunits of RNA polymerazes, initiator regions of the mRNA molecules recognized by 16S rRNA[42], signal recognition particles (SPR), start- and stop-transfer signals in the transport system of proteins within the cell[43], antigen sequences within protein and viral molecules ... the list is far from being complete.

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[39] We have carefully to distinguish between a *link* which ties a symbol to its origin – the causal agency which formed it – and the *link* which ties a symbol to its referent.

[40] The word „natural" has a double meaning. Sometimes it means a quality which originates in the „nature" of a substance (e.g. fur is „natural" in the case of an ape, and boiling at 100 C^{o} is „natural" in the case of water). Sometimes „natural" means accidental, but unmanipulated, unintegrated (natural landscape, natural ecosystem of an island).

[41] In the case of the Rosetta stone the set of Greek symbols served as indicator in the process of decipherment.

[42] Stryer, 1981 – see chapters on protein synthesis.

Conclusions

The monist premise of modern sciences requires that every possible descriptive datum is *a priori* considered as a group or subgroup of temporal, spatial and cause/effect reality. In other words the only acceptable form of dynamism has to be identified with a temporal, spatial or cause/effect phenomenon. This metaphysical premise completely eliminates a chance of an adequate description of such fundamental data as, for instance, the orientation in our surroundings. In addition many modern biological texts reveal an obvious tendency to biomorphism. Biomorphism was defined as a belief that inanimate, purely physico-chemical dynamisms have a power of „control", „production", „regulation", „stimulation", „information" .. and so on. In other words, biomorphism is a camouflage of the ancient animism. Ancient animism substituted some spurious „explanations" in place of the correct questions, and suspended the real progress of knowledge. Modern biomorphism or „technomorphism" does the same.

By a detailed analysis of some biological dynamisms we have tried to show that beyond the phenomenal sphere of experience there exists a non phenomenal sphere which is quite evident to our mind. This non-phenomenal sphere is an absolutely necessary condition of such common dynamism as cognition, signaling, direct and indirect indication[44].

We also believe that during the orientation transfer between insects true symbols are utilized, and that a close analogy exists between acoustic or graphic words of human language on one hand and the signs produced by animals on the other.

The *orientation* concept is crucial in the discussion of communication between living organisms. It refers to an epiphenomenal reality which should not be identified with temporal, spatial and cause/effect dynamism of biochemical, cytological and anatomical structures. Orientation in some physical parameters of surrounding is the most elementary form of cognition. It is non-phenomenal, and as such can be transferred to nobody, or shared with nobody. It can only be *indicated* – directly or indirectly. A close relation between the epiphenomenal and phenomenal aspects within a living body is rooted in the developmental processes of this body (mainly the embriogenetic dynamism). An undetermined, but strictly integrative dynamism merges together embryogenesis, functional activity of body organs, phenomenal (behavioral) activity and non-phenomenal (cognitive) achievements of the living whole. The nature of this integrating dynamism and its origin lies beyond the scope of this text.

BIBLIOGRAPHY

Alberts B., Bray D., Lewis J., Raff M., Roberts K., Watson J.D. (1994). *Molecular biology of the cell.* Garland Publishing, Inc., New York.

Allaby M. ed. (1996). *The concise Oxford dictionary of zoology.* Oxford Univ. Press, Oxford.

[43] Alberts *et al*. 1994/583-594.

[44] The analysis of biological and cultural analogies presented by M. I. Sereno, 1991 (see pages 485-503) ignores the non-phenomenal aspect of signaling and information transfer. The most crucial questions cannot be formulated here, because they are swept away by the biomorfic approach to chemical dynamism.

Banaszak J. (1993). *Ekologia pszczół.* Wyd. Nauk. PWN, Warszawa.

Barrington, E.J.W. (1972). *Inverterbrate structure and function.* Thomas Norton and Sons Ltd., London.

Beer C. G. (1991). *From folk psychology to cognitive ethology.* pp. 19-33; In: Ristau C.A. (ed.). *Cognitive ethology. The minds of other animals.* Lawrence Erlbaum Associates, Publishers, Hillsdale, New Jersey, Hove, London.

Benson W.W., Brown K.S, Gilbert L.E. (1975). *Coevolution of plants and herbivores: Passion flower butterflies.* Evolution, 29: 659-680.

Blackburn S. (1994). *The Oxford Dictionary of Philosophy.* Oxford Univ. Press, Oxford.

Britz S.J. (1979). *Chloroplast and nuclear migration.* pp. 170-205; In: Haupt W., Feinleib M.E. (eds). *Physiology of movements.* Springer-Verlag, Berlin.

Buck J. (1988). *Synchronous rhytmic flashing of fireflies.* II. The Quaterly Review of Biology, 63: 265-289.

Burghardt G.M. (1991). *Cognitive ethology and critical anthropomorphism: A snake with two heads and hog-nose snakes that play dead.* pp. 53-90; In: Ristau C.A. (ed.). *Cognitive ethology. The minds of other animals.* Lawrence Erlbaum Associates, Publishers, Hillsdale.

Chalifman J. (1968). *I owady są architektami.* WP, Warszawa.

Cheney D.L., Seyfarth R.M. (1991). *Truth and deception in animal communication.* pp. 127-151; In: Ristau C.A. (ed.). *Cognitive ethology. The minds of other animals.* Lawrence Erlbaum Associates, Publishers, Hillsdale.

Church A. (1942). *Term.* In: Runes D.D. (ed.). *The Dictionary of Philosophy.* Philosophical Library, Inc., New York.

De Moraes C. M., Lewis W. J., Paré P. W., Alborn H. T., Tumlinson J. H. (1998). *Herbivore-infested plants selectively attract parasitoids.* Nature 393: 570-573.

Diehn B. (1979). *Photic responses and sensory transduction in motile protists.* pp. 23-68; In: Autrum H. (ed.). *Comparative physiology and evolution of vision in invertebrates. A: Invertebrate photoreceptors.* Springer-Verlag, Berlin.

Dorland's Illustrated Medical Dictionary (1974). W.B. Saunders Company, Philadelphia.

Dröscher V.B. (1997). *Cena miłości. U źródeł zachowań godowych.* Wyd. Cyklady, Warszawa.

Frings H., Frings M. (1968). *Mowa zwierząt.* PWN, Warszawa.

Gould J.I., Towne W.F. (1987). *Evolution of the dance language.* The American Naturalist, 130 (3): 317-338.

Grabda E. (ed.). (1989). *Zoologia. Bezkręgowce.* T. III., cz. 2. PWN, Warszawa.

Griffin D.R. (1991). *Progress toward a cognitive ethology.* pp. 3-17; In: Ristau C.A. (ed.). Cognitive ethology. *The minds of other animals.* Lawrence Erlbaum Associates, Publishers, Hillsdale.

Häder D-P., Tevini M. (1987). *General photobiology.* Pergamon Press, Oxford.

Hadorn, E., Wehner, R. (1985). *Zoologia ogólna. Kontynuacja dzieła Alfreda Kühna.* PWRiL, Warszawa.

Hanh F.E. (1973). *Reverse transcription and the central dogma.* p. 8; In: F.E. Hanh (ed.). *Progress in molecular and subcellular biology.* Vol. 3, Springer-Verlag.

Harborne J.B. (1997). *Ekologia biochemiczna.* Wyd. Nauk. PWN, Warszawa.

Hart S. (1996). *Mowa zwierząt.* Prószyński i S-ka, Warszawa.

Haupt W., Feinleib M.E. (1979). *General aspects of plant movement.* pp.1-9; In: Haupt W., Feinleib M.E. (eds). *Physiology of movements*. Springer-Verlag, Berlin.

Hoppe W., Lohmann W., Markl H., Ziegler H. (1983). *Biophysics.* Springer-Verlag.

Horn D.J. (1978). *Biology of indects.* W.B. Saunders Company, Philadelphia.

Jones F.W. (1953). *Trends of Life.* Edward Arnold & Co., London.

Jura Cz. (1998). *Fotomorfogeneza.* In: Jura Cz., Krzanowska H. (eds.). *Encyklopedia biologiczna.* T.III., OPRES, Kraków

Keeton W.T. (1980). *Biological science.* W.W. Norton & Company, New York.

Kirchner W.H., Towne W.F. (1994). *Język tańca pszczoły miodnej.* Świat Nauki, 8: 54-61.

Kopcewicz J., Lewak S. eds. (1998). *Podstawy fizjologii roślin.* Wyd. Nauk. PWN, Warszawa.

Kopcewicz J., Tretyn A., Cymerski M. (1992). *Fitochrom i morfogeneza roślin.* Wyd. Nauk. PWN, Warszawa.

Koszteyn J., Lenartowicz P. SJ (1997). *Biological adaptation: dependence or independence from environment?* Forum Philosophicum Fac. Philos. SJ, Cracovia - Kraków, t. 2: 71-102.

Kullenberg B. (1961). *Studies in Ophrys pollination.* Zool. Bidrag Uppsala, Bd. 34.

Lenartowicz P. SJ (1986). *Elementy filozofii zjawiska biologicznego.* WAM, Kraków.

Leutwyler K. (1997). *Chemiczna broń bawełny.* Świat Nauki, 5 (69): 16.

Lifson S. (1994). *What is Information for Molecular Biology?* BioEssays, 16: 373-4.

Lloyd J.E. (1981). *Mimicry in the sexual signals of fireflies.* Scientific American, 245(1): 110-117.

Lorenz K. (1977). *Odwrotna strona zwierciadła. Próba historii naturalnej ludzkiego poznania*. PIW, Warszawa.

Marler P., Karakashian S., Gyger M. (1991). *Do animals have the option of withholding signals when communications is inappriopriate? The audience effect.* pp. 187-208; In: Ristau C.A. (ed.). *Cognitive ethology. The minds of other animals.* Lawrence Erlbaum Associates, Publishers, Hillsdale.

Michelsen, A. (1996). *Honey Bees: Dance-Language. The Encyclopedia of Language and Linguistic.* Elsevier Science Ltd.

Michelsen A., Andersen B.B., Storm J., Kirchmer W.H., Lindauer M. (1992). *How honeybees perceive communication dances, studied by means of a mechanical model.* Behavioral Ecology and Sociobiology, 30: 143-150.

Morris C. ed. (1992). *Dictionary of Science and Technology.* Acad. Press, San Diego.

Prosser C.L. (1978). *Sravnitel'naia fiziologia zhivotnykh.* Izd. MIR, Moskva.

Ristau C.A. (1991). *Aspects of the cognitive ethology of an injury-feigning bird, the piping plover.* pp. 91-126; In: Ristau C.A. (ed.). *Cognitive ethology. The minds of other animals.* Lawrence Erlbaum Associates, Publishers, Hillsdale.

Ristau C.A. (1991). *Cognitive ethology: An overview.* pp. 291-313; In: Ristau C.A. (ed.). *Cognitive ethology. The minds of other animals.* Lawrence Erlbaum Associates, Publishers, Hillsdale.

Searle J.R. (1980). *Minds, brains and programms.* Behavioral and Brain Sciences. Vol. 3, Cambridge Univ. Press, pp. 417-458.

Sebeok T.A. (1989). *The Doctrine of Signs, pp.* 86-95 In: Koch W.A. (ed.), *Culture and Semiotics*. Brockmayer, Bochum.

Sereno M.I. (1991). *Four analogies between biological and cultural/linguistic evolution.* J. theor. Biol., 151: 467-507.

Shropshire W. (1979). *Stimulus perception.* pp. 10-41; In: Haupt W., Feinleib M.E. (eds.). *Physiology of movements*. Springer-Verlag, Berlin.

Stetson R.H., Jastrow J. (1901). *Anthropomorphism.* In: Baldwin J.M. (ed.). *Dictionary of philosphy and psychology.* Vol. I, MacMillan and Co., London.

Stryer L. (1981). *Biochemistry.* W.H. Freeman and Company, San Francisco.

Szafer W. (1969). *Kwiaty i zwierzęta.* Zarys ekologii kwiatów. PWN, Warszawa.

Tootill E. ed. (1984). *The Penguin dictionary of botany.* Penguin Books, London.

Weisenseel M.H. (1979). *Growth movements.* p. 495; In: Haupt W., Feinleib M.E. (eds.). *Encyclopedia of Plant Physiology,* New Series, Vol. 7: *Physiology of movements.* Springer-Verlag, Berlin.

Wiens D. (1978). *Mimicry in plants.* pp. 365-403; In: Hecht M.K., Steere W.C., Wallace B. (eds.) *Evolutionary biology.* Vol. 11, Plenum Press, New York.

Wilson E.O. (1979). *Społeczeństwa owadów.* PWN, Warszawa.

Wolken J.J. (1975). *Photoprocesses, photoreceptors and evolution.* Academic Press, New York.

Wuellner B. S.J. (1966). *A Dictionary of Scholastic Philosophy.* The Bruce Publishing Company, Milwaukee.

Zurzycki J., Michniewicz M. (1985). *Fizjologia roślin.* PWRiL, Warszawa

TERMINOLOGIA OPISU PRZEKAZYWANIA INFORMACJI POMIĘDZY ORGANIZMAMI

Streszczenie

W filozoficznej warstwie współczesnej nauki można dostrzec dwie sprzeczne tendencje: redukcjonizm i animizm.

Z jednej strony monizm materialistyczny dąży do opisania całej rzeczywistości w kategoriach prostych relacji przyczynowo-skutkowych i zjawisk przestrzenno-czasowych. Monistyczna teoria ewolucji biologicznej usiłuje wypełnić lukę pomiędzy psychiczną dynamiką człowieka a psychologicznymi możliwościami zwierząt – zwłaszcza małp człekokształtnych – oraz lukę pomiędzy dynamizmami czysto mineralnymi a dynamiką istot żywych. Stąd nauka współczesna ma wyraźny charakter redukcjonistyczny, zmierzając do uproszczenia i ujednolicenia obrazu rzeczywistości.

Z drugiej strony – w obliczu nieomijalnej skądinąd złożoności i bogactwa dynamizmów, ujawnianych dzięki postępowi obserwacji i analiz biologicznych – nauka współczesna bezwiednie sięga do praktyki, która nie da się odróżnić od dawno i słusznie wyśmianego animizmu.

Na czym polega animizm? Polega on na przypisywaniu materii martwej cech istoty żywej. Moglibyśmy – przez analogię do antropomorfizmu – nazwać tę formę animizmu *biomorfizmem.* W rezultacie, oczywista przepaść pomiędzy tym, co żywe, a tym, co nieżywe zostaje zatarta. O ile redukcjonizm stwierdza, że życie „jest *tylko* bardziej skomplikowaną formą zjawisk mineralnych", o tyle, z drugiej strony, biomorfizm przypisuje dynamizmom materii martwej zdolność „kontroli", „stymulacji", „selekcji", „informacji", „produkcji" życia.

> „Fotomorfogeneza – ogół zmian morfologicznych w organizmie /.../ zależnych od wpływu promieniowania słonecznego. /.../ światło *zapobiega* pozbywaniu się przez organizm aparatury fotosyntetycznej /.../ *indukuje* fotoperiodyzm. Światło jest tutaj źródłem informacji, a nie energii /.../ *Informacja* przekazywana jest za pośrednictwem specyficznych fotoreceptorów /.../ Ostatecznym efektem jest /.../ np. *zahamowanie wzrostu* łodygi, *szybszy wzrost* liści, *zmiany przekroju* rośliny, *zakwitanie, kiełkowanie* nasion /.../ *Wszystkie te zmiany są wynikiem oddziaływania promieniowania na procesy metaboliczne, w tym na ekspresję wielu genów."* (Jura, 1998 – podkreślenia JK/PL).

> *„płetwy i ruchy ryb odwzorowują w swych formach hydrodynamiczne właściwości wody,* która ta posiada niezależnie od obecności bądź nieobecności w niej wiosłujących płetw. /.../ *Oko jest,* jak to słusznie dostrzegł Goethe, *odwzorowaniem słońca oraz właściwości fizycznych przysługujących światłu* niezależnie od tego, czy jakieś oczy je widzą. Również *zachowanie się zwierząt i ludzi stanowi obraz środowiska* w tej mierze, w jakiej jest do niego przystosowane" (Lorenz, 1977/37 – podkreślenia JK/PL).

Czy w powyższych tekstach nie widać podobieństwa do myśli wyrażanych przez Platona?

> „/.../ Słońce jest nie tylko *autorem* widzialności wszystkich rzeczy widzialnych, ale ich powstawania, odżywiania i wzrostu" (*Republika*, 509, b. 2).

Mimo że tendencje animistyczne są dziś bardzo żywe i wpływowe (hipoteza Gai), nie czyta się o nich – rzecz zastanawiająca – w filozoficznych traktatach teoriopoznawczych. Teoria ludzkiego poznania pomija również to, co wiemy dziś na temat psychologii zwierząt. Opisy poznania naukowego, spory na temat wiarygodności poznania tkwią w ograniczonym kręgu odbiologizowanej antro-pologii. Człowiek w większości traktatów teoriopoznawczych przestał już być *animal rationale* – stał się abstrakcyjną mentalnością emocjonalno-intelektualną.

Filozoficzna otoczka i związana z nią terminologia współczesnej nauki zupełnie – naszym zdaniem – nie przystaje do opisowej sfery nauk przyrodniczych, zwłaszcza biologii, którą się zajmujemy. Tu tendencje redukcjonistyczne i biomorficzne są stosunkowo łatwe do wytropienia. Jednak język opisu zjawisk biologicznych często podlega wpływom założeń filozoficznych materializmu, redukcjonizmu i animizmu. Dlatego właśnie postanowiliśmy zanalizować czysto empiryczne znaczenie pewnych kluczowych pojęć, związanych z dynamiką typu biologicznego i orientacją stwierdzaną u najprostszych nawet organizmów żywych.

Jak rozumiemy termin „orientacja"? Orientacja to zdolność, dzięki której organizm – znajdując się w nieprzewidywalnym otoczeniu – wykazuje korzystną dla siebie dynamikę prawie perfekcyjnie skorelowaną z aktualnymi, wewnętrznymi właściwościami przedmiotów składających się na to środowisko. Każdy organizm żywy wykazuje tendencję do selektywnego rejestrowania dynamiki otoczenia – czyli ma zdolność percepcji. Ta tendencja występuje w oczywisty sposób już w embriogenezie, gdy organizm konstruuje struktury organów ciała (przykładem jest budowanie organów zmysłowych i ośrodków nerwowych u zwierząt). Elementy otoczenia mogą być przedmiotem percepcji, o ile wykazują jakąś dynamikę, choć nie każda forma dynamiki otoczenia jest przez organizm rejestrowana. Czasami percepcja polega też na aktywnym badaniu biernego skądinąd przedmiotu lub aspektu przedmiotu (np. ruchy nutacyjne pędów fasoli, powoju, grochu). Dzięki percepcji organizm zdobywa i uaktualnia wciąż swoją orientację w otoczeniu.

W niniejszej pracy przeanalizowano proces rozpoznawania się samca i samicy świetlików, które korzystają ze skomplikowanej i zróżnicowanej rasowo sygnalizacji świetlnej. Rozróżniono pomiędzy „wpływami" otoczenia i ich intensywnością z jednej strony a „progami wrażliwości" i „bodźcami" z drugiej. *Wpływ* oznacza czysto fizyczno-chemiczną, proporcjonalną do jej intensywności, zdolność energii do produkowania efektów. Pewne formy energii fizyczno-chemicznej mogą być monitorowane przez organizm żywy, który odpowiednio do intensywności takiego wpływu może nań reagować gamą swoistych, wewnętrznych zachowań. Z literatury biologicznej wynika, ze termin „bodziec" jest używany tylko tam, gdzie zachodzi percepcja danej formy energii i biologiczna reakcja związana z tą percepcją. Zatem ścisłe, biologiczne znaczenie terminu „bodziec" odnosi się do tej dynamiki, która łączy percepcję z reakcją. Nie ma zatem uzasadnienia praktyka utożsamiania „wpływu" z „bodźcem". O wpływach można mówić w kontekście dynamizmów materii martwej, natomiast „bodźce" oznaczają pewien szczególny typ wewnętrznej dynamiki organizmu. Ten sposób rozumienia „bodźców" był pewną normą terminologiczną przełomu XIX i XX wieku, a nawet pierwszej połowy wieku XX. Dopiero w drugiej połowie naszego wieku doszło do zatarcia różnicy pomiędzy znaczeniem terminu „wpływ" i terminu „bodziec".

Następnie zastanawialiśmy się nad rozróżnieniem pomiędzy terminem „bodziec" a terminem „sygnał". Bodziec jest to wytworzona przez jakiś organ ściśle określona porcja energii, przekazana selektywnie do innego organu i powodująca w nim określoną zmianę fizyczną. „Sygnał" natomiast okazał się dynamiką bardzo złożoną, implikującą rozróżnienie pomiędzy nadawcą a odbiorcą z jednej strony, pomiędzy precyzyjnym oznaczaniem przestrzeni, czasu oraz przekazywaniem orientacji, czyli „znaczenia" z drugiej strony. Proces sygnalizacji tylko myślowo może być wyabstrahowany z kontekstu poznawczego, a dynamika poznawcza tylko myślowo może być wyizolowana z procesów rozwoju (embriogenezy) organizmu.

W drugiej części pracy zajęliśmy się kwestią zdobywania orientacji w otoczeniu i przekazywania tej orientacji przy pomocy znaków. Modelem tego rodzaju dynamiki jest wyszukiwanie przez pszczoły-zwiadowczynie nowych źródeł pokarmu oraz przekazywanie orientacji w tych źródłach innym pszczołom.

Okazało się, że orientacja zwiadowczyni w źródle pokarmu jest bardzo zróżnicowana, oraz, że poszczególne elementy tej orientacji są komunikowane innym pszczołom przez odrębne formy przekazu. W przekazie orientacji, dotyczącej odległości i kie-

runku źródła pokarmu, pszczoły stosują system znaków, których znaczenia nie można odgadnąć na podstawie praw fizyczno-chemicznych. Są to zatem systemy znaków *sensu stricto,* czyli *symboli.* Bez „wtajemniczenia" wrodzonego bądź wyuczonego, te znaki nie przekazują orientacji. Inne cechy nowego źródła pokarmu są przekazywane pszczołom w formie bezpośredniej. Dotyczy to np. zapachu lub smaku pokarmu.

Na podstawie powyższych danych doszliśmy do wniosku, że przekaz orientacji danej pszczoły dokonuje się poprzez dynamikę *wskazywania.* Wskazówki (wskaźniki) mogą być bezpośrednie (niezakodowane) lub pośrednie (zakodowane). Każda wskazówka ma złożoną strukturę, w której trzeba wyróżnić trzy elementy. Jeden element to wskazywany przedmiot lub aspekt jego rzeczywistości, drugim elementem jest materialna struktura wskazówki, trzecim zaś jest więź pomiędzy nimi. Jest rzeczą oczywistą, że odbiorca przekazu musi zorientować się we wszystkich tych trzech elementach. We wskaźnikach pośrednich „wskazówka" ma charakter sztuczny. Dlatego właśnie więź z wskazywanym przedmiotem jest więzią arbitralną, niemożliwą praktycznie do odgadnięcia.

Na tle tych analiz ukazała się wyraźna i bliska analogia pomiędzy strukturą „wskazówek językowych" („słówek" danego ludzkiego języka) a strukturą wskaźników pośrednich używanych przez niektóre zwierzęta. Tomistyczne pojęcie „terminu" stanowi schemat dobrze ujmujący istotne elementy obu tych form wskazówek. W pojęciu „terminu" zawiera się bowiem element „znaczka" (ang. *mark*), element więzi (mniej lub bardziej arbitralnej) i element odniesienia (referent, desygnat). Korzystając z tego schematu, skonstruowaliśmy pojęcie *idealnego znaczka*, *idealnej więzi* oraz *idealnego desygnatu.*

Idealny znaczek (czyli symbol) to taka struktura materialna, która nie ma naturalnej więzi z żadnym desygnatem. Stąd onomatopeja, piktogramy, a tym bardziej fotografie lub tropy na śniegu nie są idealnymi znaczkami. *Idealna więź* to taka więź pomiędzy wskaźnikiem a wskazywanym obiektem, która pozwala, bez informacji zewnętrznej, przejść od jednego do drugiego. Taka więź istnieje np. pomiędzy fizyczną przyczyną a jej fizycznym skutkiem. Wreszcie *idealny desygnat* jest to prawidłowa orientacja we wskazywanym elemencie rzeczywistości. Gdy desygnat nie zawiera prawidłowej orientacji, wtedy dochodzi do tzw. decepcji. Decepcja jest stosowana zarówno przez zwierzęta jak i przez rośliny, by uchronić się przed drapieżnikiem, szkodnikiem, lub by łatwiej złowić ofiarę.

Przyjęte rozróżnienia i uściślenia terminologiczne pozwalają bardziej precyzyjnie opisywać i rozróżniać między sobą takie procesy, jak formowanie i informowanie, poznawanie, orientowanie, zapamiętywanie, wskazywanie, tworzenie symboli, nazywanie, kodowanie, odkodowywanie, szyfrowanie, rozszyfrowywanie.