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Elf Sternberg

Introduction

In 1881 C. Darwin stated:

If worms have the power of acquiring some notion, however rude, of the shape of an object and over their burrows, as seems to be the case, they deserve to be called intelligent; for they act in nearly the same manner as would man under similar circumstances [1].

In 1906 H.S. Jennings argued that even the behaviour of Protozoa may be termed “intelligent” [2] In his work of 1915 E. Heron-Allen argued that one-cellular Foraminifera dispose of a kind of intelligence [3]. At that time, it sounded not simply revolutionary: it was a heresy! Heron-Allen has observed that the Foraminifera select only the grains of sand of specific parameters to build a test around their one-cellular bodies. Still later, in 1941, L. Cuénot attributed some kind of intelligence to each cell of a living organism [4]. Accordingly, intelligence is not a “divine gift”, which only human individuals dispose of, but an information processing strategy ubiquitous in the world of living creatures.

In science, what might be termed “Foraminifera strategy” is often described, rather pejoratively, „eclectic“. However, whole science is in fact eclectic, because just the mental diversity underlies its fertility. On the other hand, methodologically pure „inbreeding“ wallows in tautologies and finally leads to intellectual impotence.

It is worth noting that eclecticism makes the very heart of the greatest intellectual achievement of humanity, i.e., the culture. Thanks to invention of speech, it became possible to make use of valuable ideas, no matter, when and where they are conceived. In other words, lan-
guage enabled elimination of temporal and spatial constraints existing in reality identifiable by senses. In fact, the term "eclectic" is by no means pejorative.

Symptomatically, in such an approach the intelligence cannot be regarded as a highest developed information processing technique in living beings. This made a basis for specific definitions of intelligence, intuition and instinct [5], which together make a system (intellect), and not a sum. In fact, the intelligence is the most primeval of them. This testifies to the fact that in science terminology is not a passive tool for description, but an active instrument co-creating the science.

1. Truth, Freedom and (Motor) Science

In my papers from the series A scientific evening… I follow the same strategy as Foraminifera do. In this article, the first eligible „grain of sand” is the idea by P. Feyerabend that the development of human knowledge results from a specific interplay of Truth and Freedom [6]. In short, the sober Truth orders the achievements if human mind and makes them useful, whereas the day-dreaming Freedom makes the leading edge of intellectual progress. The former is rather safe, the latter – risky. This is expressed by another „grain of sand” – the motto to this paper.

The Freedom exists in the sphere of abstraction, the Truth – in reality. They are only indirectly dependent on each other. Where a specific resonance between Freedom and Truth occurs, the Science is being born; the term “resonance” in this respect has been used by M. Heller [7]. However, sober Truth underlies properly ordered science, whereas flighty Freedom – generously inventive philosophy. The former is intellectually stiff, the latter – flexible, so their ways only in some short fragments may fall into resonance – in those regions the science is being born – and then inevitably have to part of each other.

Such a relation underlies a general mechanism of science creation. In physics, the ways of Truth and Freedom run rather close to each other, hence detection of a specific resonance is quite easy. Probably because of this, just the physics developed explosively since 17th century. However, in living beings – and especially in humans – the mechanisms of such a resonance, underlying the motor behaviour, is much more complicated. The relations between Truth and Freedom are by far less obvious and much more complicated. Roughly, they are determined by many factors of various resonance frequencies. Sometimes only one of them falls into resonance with external influences. Such a resonance is being termed “parametric resonance” [8]. In motor control in humans, this is still more complicated, because particular parameters are also of various modalities (proprioceptive, contactceptive, teleceptive, verbal and symbolic) [5]. This is why this branch of science cannot rely on experimental observations to such an extent as, say, physics. Consequently, in motor control the share of mental speculations is by far greater than that of observations or measurements. Here the appeal of mathematician and physicist A. Sokal sounds especially instructively: Don’t ape the natural sciences! [9]. Sometimes apparent, superficial similarities may result with analogous relations being observed in reality, yet the mechanisms underlying the phenomena or processes under consideration may be diametrically different. This is why in motor control experimental research cannot support scientific reasoning to such an extent, as it is in physics.

2. Certainty, reliability and progress in science

However difficult its creation may be, just the abstract theory makes the very heart of science. This may be illustrated with the Street Lamp Analogy [10]. Let us develop this idea to a greater extent. The idea of “abductive reasoning pillar” of the lamp bases on theories of both C.S. Peirce [11] and J.S. Bruner [12]. In short, theory is being actively created by a scientist (Bruner) using the methodology of abduction (Peirce).

The “output end” of science may be regarded as a specific interplay of abstract certainty and real reliability [5]. The former is a “daughter” of theory, born as a result of deduction, which – by definition – is infallible. However, the latter is the “granddaughter” of theory, which should be unfailling. Unfortunately, abstract certainty not always is followed by practical reliability.

In science, the language is not a passive tool for reality description, but an active instrument for science creation [5, 13]. The differentiation of the terms “certainty” and “reliability” may underlie the specific model of science development. At first, newly created theory is being applied rather timidly (Fig. 1). Consequently, such an “underestimated theory” is not used in full and has some “application reserves”.

By the way. Such an interpretation of language may contribute to simplification of the division of language functions into communicative and representative, invented by N. Chomsky [14]. In fact, as the essence of such division may be regarded time perception. If linguistic representation concern items, phenomena or processes, which exist or happen “here and now”, this might be identified with the communicative function of language. It consists in simple assigning a specific word to a given item, phenomenon, or process. The other function – which may be roughly associated with the representative one as by Chomsky – includes the active time perception. It enables extending the verbal descriptions of reality beyond the limited scope of “here and now”, far into
past and into future. Especially the latter is responsible for probably the highest developed intellectual potentiality of a living creature: the ability to anticipation. Its meaning in motor control – the “model of desired future” – has been illustratively described by I.M. Feigenberg [15]. To sum up, one might imagine only one function of language – the representative one – with division into time independent and time dependent sub-categories.

Along with time passing, the new theory becomes more and more “tamed”. Consequently, one has to do with the process termed “testing the limits” [16]. As a result, finally the regions of actual certainty and possible reliability coincide with each other (Fig. 2). In such a model the limits of “possible reliability” and the “working reliability” overlap each other.

While looking at Fig. 2 one may learn that in such a model a theory is not an “absolutely versatile” mental structure, but it is tightly (though usually indirectly) associated with a specific portion of reality. Moreover, a specific interplay between certainty and reliability endows it with some flexibility.

The proposed interpretation of relation between certainty and reliability enables another look at the principle of refutability by K.R. Popper [17]. In this paper, we will treat him not as an unshakeable intellectual monument, but as an intellectual sparring-partner. In fact, not an unconditional esteem – however justified it may be – but a barbarian “sparring-partnerism” makes the “engine” of science development (and sometimes progress).

According to Popper, if a given theory does not produce reliability, then it should be rejected. This would be justified if a theory were a mental structure, shaped once and for all. However, according the constructivist paradigm by J.S. Bruner, a theory is rather freely shaped by a scientist. R.A. Schmidt wrote:

> Since laws are the product of human creativity, different laws can be formulated by two different individuals who are examining the same observations. Laws do not automatically spring forth from the facts [18].

Accordingly, laws or theories are in fact rather “plastic” mental structures, liable to corrections. This makes a basis for “logic of loops” as by M. Heller [19]. Thus, an imperfect theory may be improved, and not necessarily refuted.

If a given theory works well in practice (i.e., produces reliability) then it becomes more and more trustworthy and… petrified. So the paradigms according to T.S. Kuhn are being born. They may become dangerous to scientific progress, because, as Kuhn – the author of theory of scientific revolutions – argued, “rules… derive from paradigms, but paradigms can guide research even in the absence of rules” [20]. Paradigmatic petrification foretells
the scientific revolution and destruction of a “stiff” paradigm. Let us remember that the inventive Freedom has to be flexible. Therefore, it cannot be harnessed by petrified Truth, and Science is being born only where Truth and Freedom go hand in hand. However, if stiff constraints of Truth become too hard for Freedom, the latter casts off them. Just this – the divergence of Truth and Freedom – makes the basis for Kuhn’s scientific revolution.

However, each theory is a simplification and, as a result, its field of validity is limited. When one tries to apply it beyond this field (Fig. 3, light grey ring), it produces actual certainty, indeed, but not the working reliability.

The light grey ring in the Fig. 3, where the theory turns out to be irrelevant, makes the action space for a cognitive dissonance [21]. This stimulates one of the most marvellous mechanisms “invented” by evolution: the feedback [5].

Consequently, the process of testing the limits might be termed “pursuit of irrelevancy”. In the field of social sciences its equivalent is the Peter principle that “in a hierarchy, every employee tends to rise to his level of incompetence” [22].

If a given theory does not work in practice, then it does not necessary mean that the theory should be refuted (or “disproved”), but that it went beyond actual limits of its possible reliability (Fig. 3). Therefore, a “not-working theory” should be perfected rather, and not refuted, as it K.R. Popper suggested. In short, the dissonance should be killed, and not the theory. Only if this turns out to be impossible, the theory may be put into pasture or even buried. However paradoxically it may sound, perfection of a theory bases on the fact that it cannot be perfect, and thus opens the way for feedback.

By the way: Not accidentally, the word “disproved” has been written in quotation marks. Theory “resides” in the sphere of abstraction, hence it is valid by logical proof, and not by experimental verification. The latter may testify not to correctness of the theory, but to its applicability (or not) in practice.

Unfortunately, though the certainty seems to be obvious, the limits of applicability and reliability of a given theory are not easily visible. This was illustratively expressed by novelist J. Rydzewska, who wrote:

…and, besides, the Shreckinger’s cat not exactly was a joke, because at definite point such joke becomes truth, but nobody knows, where precisely that point lies, and why just there, and this lack of knowledge makes a problem, and yet the key to solving the problem [23].

This citation concerns the famous physical paradox termed “Schrödinger’s cat”. While applied the quantum physics logics to the phenomena and processes observable in reality, then one may imagine a cat, which is both
dead and alive. In the world where we live, it is contradictory to the common sense.

Consequently, in science the problem is not to “prove” or “disprove” the validity of a theory, but to delimit its field of applicability. Creation of quantum physics did not cause putting the Newtonian physics to the pasture. M. Heller remarked:

*It is almost regularity in the history of physics that the mathematical structure of a given theory becomes known in full only when this theory has already been replaced with a new one* [7].

The same author argued that the progress in science is possible only because of its self-limiting, i.e., looking for answering the questions that can be answered. In other words, the dark grey circle of working reliability should be extended gradually. However, this may happen only when the light grey ring of a “beyond limit certainty” exists. Just there appears necessity of improving the already existing theory, just there “resides” a cognitive dissonance, which might be termed “engine of development”. So, in science important are not only the successful scientists; also those unsuccessful are – even more – necessary to pave a way for progress. In this respect highly illustrative is the statement by L. Tomlin that “the road to success is always under construction”.

The light grey ring in Fig. 3 evokes one more reflection. An idea analogous to self-limiting of science by Heller [7] has been expressed by J. Cohen and I. Stewart, who stated that the “A Theory of Everything would have the whole universe wrapped up. And that’s precisely what would make it useless” [24]. This is why the existence of a cognitive dissonance is necessary for those who really create Science (with great “S”).

The situation as in Fig. 3 deserves a more detailed analysis. “Genuine scientists” do not accept going beyond the limits of working reliability; the dangerous region beyond these limits they term “not scientific” or “daydreaming”. If the phenomena from the light grey outer ring in Fig. 3 become more and more important in daily practice, the Kuhn’s scientific revolution becomes necessary. However, it may be done by “daydreamers”, and not by “genuine scientists”. This idea has been expressed by many Great Minds. According to H. Poincaré, “it is by logic we prove; it is by intuition we discover”. M. Planck argued, “Scientific discovery and scientific knowledge have been achieved only by those who have gone in pursuit of it without any practical purpose whatsoever in view”. Engineer W. von Braun stated: “Research is what I’m doing when I don’t know what I’m doing”. Polymath C.F. Kettering remarked that

Figure 3. Overestimated theory; the actual certainty goes beyond the working reliability
“An inventor is simply a fellow who doesn’t take his education too seriously”. Probably most frivolous and witty formulation of this idea comes from R. Feynman, who said that “Physics is like sex: sure, it may give some practical results, but that’s not why we do it”. However, though wallowing in the light-grey ring in Fig. 3.1 needs what may be termed “higher order thinking”, the way toward progress is lined with dead bodies of daydreamers, mercilessly exterminated by “genuine scientists”, armed with infertile, yet efficient scientific paradigms.

3. Theory creation in motor control

However difficult its creation may be, just the abstract theory makes the very heart of science. Not the “naked” experimental results obtained even with the most sophisticated technical laboratory equipment and flawlessly processed statistically. As it J. Cohen and I. Stewart stated, “At least 999 out of thousand scientific papers are about complex details, but the one that we treasure and for which we award a Nobel Prize is the one that reveals a new simplicity. It is as if simplicities are all around, but scattered rather thinly. Some scientists are rather good at laying hands on them; they must have the right kind of mind, seeing the world with unusual clarity. Albert Einstein specialized in big simplicities, and so did Paul Dirac, Gregor Mendel, and Dimitri Mendeleev” [24].

The latter needs a comment, also from J. Cohen and I. Stewart, who remarked that “A theory is a kind of code that transforms complicated messages from nature into much simpler ones” [23]. From such a perspective, the science as a whole may be regarded as a universal, all-embracing process of searching for simplicity. It makes the collected knowledge graspable for human minds and thus useful in practice.

Unfortunately, scientific simplicity cannot spring out automatically from the experimental results. It is a product of mind rather, and not an already existing item which needs only be discovered. In this respect, arduous, daring, risky scientific thinking is absolutely necessary. And unavoidable.

As already mentioned, in physics the “real body” of phenomena and processes and its “mathematical gown” so tightly fit to each other that new observations may be nearly directly transformed into theory correction and perfection. Unfortunately, the tangible reality, where the motor behaviour of living beings, including humans, takes place is so distant to its abstract representation – theory – that the observations cannot be translated directly into a theory and vice versa. To be brief, in biology and – all the more – in psychology and motor control, the “abductive pillar” as in Figs. 1 through 3, has to be by far higher than that in physics. Therefore, in motor control sheer “aping the natural science” seems to be especially fruitless, however technologically advanced and “fashionable” it can be. In short, the motor control scientific matter is for far-sighted daydreamers, and not for learned laboratory workers, with their noses in computer monitors.

Conclusion

In a nutshell, while seen from the perspective presented in this paper, the creation of science consists in incessant going beyond the limit of dark grey “possible reliability” circle, in continuous wallowing in light grey ring as in Fig. 3. In this respect, let us remember the motto to this paper: “Eagles soar, but weasels never get sucked into jet engines”, which may be regarded as a leading idea of “genuine scientists”. Jet engine is mindless and indifferent to novelties – like Kuhn’s scientific paradigm. Unfortunately, the essence of motor science resides at such high regions of abstraction, where intellectual soaring is absolutely necessary. Therefore, one may confront the timid (and non-productive) aphorism by E. Sternberg with the brave (and productive) words of Yeshua Ha-Nozri – the character from “Master and Margarita” – that “Cowardice is the most terrible of vices”[25]. Also in science. Particularly in motor science.

References

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