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ELUDING THE DEMON – HOW EXTREME PHYSICAL INFORMATION APPLIES TO SEMIOSIS AND COMMUNICATION

ILUDINDO O DEMÔNIO – COMO A INFORMAÇÃO FÍSICA EXTREMADA SE APLICA À SEMIOSE E À COMUNICAÇÃO

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Abstract: *C.S. Peirce states that a sign represents only some aspect of an object, which means that no representation can be perfect. The form – or information – grounding the sign's ability to represent its object is always deficient in some measure. If we take the difference between the form of the object and the form represented in the sign to be a physical one, the flow of semiosis can be taken as a flow of information, and consequently, a knowledge game by which the interpretant tries to improve the information grounding the sign, amplifying its ability to represent. The other player in the game, the dynamical object, takes the role of a demon, always changing its form to escape a complete symbolic interpretation. The Extreme Physical Information (EPI) theory, formulated by the American physicist Roy Frieden in 1995 and 2000, shows how the pay off of this game is always on the side of the interpretant. This explains why semiosis is teleological and naturally tends towards an increase of information and knowledge in a community of interpretants pragmatically engaged in the inquiry by means of communication. It also explains why intelligence can evolve among living creatures – their observations tend to be accurate, and accuracy is a prerequisite for effective behavior. It results that their fitnesses go up, so that evolution favors their existence.*

Key-words: *Semeiosis. Extreme phisical information. Peirce. Fisher. Frieden. Communication.*

Resumo: C. S. Peirce afirma que um signo representa apenas algum aspecto de um objeto, o que implica que nenhuma representação pode ser perfeita. A forma – ou informação – fundamentando a habilidade do signo para representar seu objeto é sempre, em alguma medida, deficiente. Se tomarmos a diferença entre a forma do objeto e a forma representada em um signo como sendo física, o fluxo da semiose pode ser considerado como um fluxo de informações, e conseqüentemente, um jogo de conhecimento por meio do qual o interpretante tenta melhorar a informação que fundamenta o signo, ampliando sua habilidade de representar. O outro jogador envolvido, o objeto dinâmico, faz o papel de demônio, sempre mudando sua forma para escapar a uma completa interpretação simbólica. A teoria da Informação Física Extrema (IFE), formulada pelo físico norte-americano Roy Frieden (1995 e 2000), mostra como a compensação desse jogo sempre favorece o interpretante. Isto explica porque a semiose é teleológica e tende naturalmente na direção de um aumento de informação e conhecimento em uma comunidade de interpretantes pragmaticamente engajada na inquirição por meio da comunicação. Isso também explica porque a inteligência evolui entre as criaturas vivas – suas observações tendem a ser precisas e a precisão é um pré-requisito para o comportamento eficaz. Resulta disto que suas aptidões crescem de tal modo que a evolução favorece sua existência.

Palavras-chave: Semiose. Informação física extrema. Peirce. Fisher. Frieden. Comunicação.

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1. Introduction

The American philosopher Charles S. Peirce is known to be the creator of pragmatism, as well as one of the founders of semiotic as a general theory of signs. These two major intellectual contributions were developed basically during the same period, from the middle 1860´s to the beginning of the 20^{th} century, but only after 1905 Peirce's pragmatism (or pragmaticism, as he started to called it) and his mature realistic semiotic began to merge into a broader philosophical architecture, in which cosmology and metaphysics also play key roles. This is the same year in which Peirce started to define the sign as a medium for the communication of a form, putting emphasis on the third branch of semiotic: rhetoric or methodeutic.

Peirce defines his pragmatism as a method devised to clear up concepts. Its efficiency depends on being adopted by a community of inquirers honestly interested in finding out the truth of such concepts. It is understandable that communication, and thus semiosis, must have an important role in the pragmatic search for clear concepts.

Peirce's long aimed proof of pragmatism should involve semiotic and, more specifically, the answer to the questions: how can we trust that the transmission of information from the dynamic object to the intepretant will lead to the *summum bonum*? What does guarantee that the growing of information in the symbol – and concepts are species of symbols – improves our knowledge about the dynamic object, making its representation ever more precise?

Peirce did not have these assurances in hand. Actually, he struggled for more than 30 years trying to produce a well-formed definition of sign that could shed some light into theses questions, but died without ever being satisfied with any of his dozens of attempts. The system of Existential Graphs (EG), a kind of knowledge game developed mostly after 1905, was another tool for the proof of pragmatism that ended up without a final version.

What seems to be missing in the equation among pragmatism, semiosis and Existential Graphs is a theory of information that would describe how is it possible that the form of the dynamical object could be transmitted to the interpretant. It should be a theory able to encompass falibilism (the doctrine that our knowledge starts with weak assumptions, or hypothesis, that can be discarded or reformulated by the confrontation with experience), synechism (the doctrine of continuity and the reality of law-like phenomena[1]) and tychism (the doctrine that chance or non-deterministic phenomena bring novelty, developing new characters and growing information).

This theory of information could not be that the one that Claude Shannon developed in the 1940´s, which is global and does not explain how symbols grow as *ens rationis* locally determined by the community of their users. We argue that Extreme Physical Information (EPI) formulated by one of the authors (Frieden, 2000) gives this needed Theory of Information to solve the Gordian knot. In fact, Peirce states that a sign represents only some aspect of an object, which means that no representation can be perfect. The form – or information – grounding the sign's ability to represent its object is always deficient in some measure.

If we take the difference between the form of the object and the form represented in the sign to be a physical one, the flow of semiosis can be taken as a flow of information, and consequently, a knowledge game by which the interpretant tries to improve the information grounding the sign, amplifying its ability to represent. The other player in the game, the dynamical object, takes the role of a demon, always changing its form to escape a complete symbolic interpretation. The Extreme Physical Information (EPI) theory shows how the pay off of this game is always on the side of the interpretant.

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1 Synechism would explain, for instance, why the universe seems to be governed by differential equations (c.f. CP 6.490).

This explains why semiosis is teleological and naturally tends towards an increase of information and knowledge in a community of interpretants pragmatically engaged in the inquiry by means of communication. It also explains why intelligence can evolve among living creatures – their observations tend to be accurate, and accuracy is a prerequisite for effective behavior. It results that their fitnesses go up, so that evolution favors their existence. All this is in perfect accordance with Peirce's broad view of semiotic, intelligence and pragmatic inquiry.

2. An information-oriented universe

It appears that both nonliving and living systems tend to evolve toward ever higher levels of complexity. This is attested to, e.g., by the proliferation of power-law phenomena in both nonliving and living systems. Thus, an initial system of hydrogen atoms evolved into ever more complex atoms such as helium, carbon, iron, etc. Likewise, life evolved from the simplest single-celled bacteria to creatures with ever-more cells and ever-higher complexity. Complex systems likewise convey higher levels of information. The human brain is notably the most complex system in existence. Thus, intelligent life, in particular, seems to be favored by this increase of information in the long run. Peirce, in what might have been one of the first uses of the word information in the scientific context, in 1893 states that:

> Analogous to the increase of information in us, there is a phenomenon of nature-development by which a multitude of things come to have a multitude of characters, which have been involved in few characters in few things. (CP 2.419)

A stronger version of this statement is that the universe, more than allowing such life, actually favors it through choice of its fundamental constants and physical laws (the "Harris universe").[2]

In Peircean terminology, theses laws and constants are legisigns (generals active as probability laws) that convey information. These provide a special niche for ecological survival of intelligent creatures, by rewarding curiosity and learning with higher fitness (defined as the mean number of offspring per generation that survive and reproduce).

How does a universe come about that provides such a niche for intelligence and information? Surprisingly, by considering this question we will arrive at one definite approach for deriving the probability laws of science. This seems strange, especially since no detailed knowledge of physics or biology is involved in forming the approach (although some will be needed in applying it.)

The following set of axioms lead to the answer:

AXIOMS FOR EPI

(I) The system (universe) is a complex legisign that must obey the basic rules of consistency (e.g., both A and not-A cannot be true). This does not rule out the existence of non-deterministic phenomena, but implies that the universe as a system is governed by law-like phenomena that subsumes and continuously incorporate novelty into its niches of information.

[2] E. Harrison, Cosmology: The Science of the Universe (Cambridge Univ. Press, UK, 2000). In one chapter of the book, Harris studies the significance of Dirac's unitless physical constants, emphasizing how their particular numerical values happen to lie within the often narrow ranges that can allow the formation and evolution of life. He believes, but of course cannot prove, that they are so fine-tuned to our existence that there seems to be purpose behind them. That is, they favor the existence of life. That most distant galaxies are recently found to contain all the necessary hydrocarbons for producing life-as-we-know-it seems to support such a conjecture.

(II) This consistency allows mathematics, as a scientific language based on symbols, to be utilized (up to limitations by Godel's incompleteness theorem) in order to analyze the system. Thus E. Wigner's famous comment on the "unreasonable utility of mathematics" in physics (and all other sciences) is actually now deduced.

(III) The system must obey a fixed, not random, set of constants (usually called the "universal physical constants") and laws. Random ones, by comparison, would give rise to a chaotic system, incapable of further evolution for they would not develop into legisigns. What defines these laws?

(IV) The system obeys laws of science. A law of science both obeys a body A of mathematics and an observed body B. Thus the net system law is actually the process AB. All scientific knowledge ultimately traces to the observation of parameters. Hence the observation B is of a parameter. Let the mathematics A provide general information level J about the parameter value, which is observed B as level I. The net acquired knowledge in process AB is any measure $f(I,J)$ of the disparity between I and J, such as $I - J$ or I/J. Since any observation or interaction perturbs the systems involved, both I and J are perturbed, and resultingly, $f(I,J)$. This is equivalent to the dual EPI principle, $I - J = extremum$ and $I/J = constant$ (see Sec. 4 below).

(V) The system evolves over time. In what direction? Of course it must obey the 2nd law of thermodynamics, which would tend to favor increases in disorder. However, for the effect (IV) to be meaningful it must give zero perturbation even in the presence of maximally complex systems, namely those with independent degrees of freedom. Hence, maximally complex systems tend to be stable. Therefore, with the passage of enough time, an abundant level of potential information comes into existence. This represents increased complexity of structure. Particular system examples are crystal growth, biological growth, etc. This is done, following Peirce, by a kind of naturalized process of thought, made possible by the action of signs, or semiosis, in the natural world:

> "Thought is not necessarily connected with a brain. It appears in the work of bees, of crystals, and throughout the purely physical world; and one can no more deny that it is really there, than that the colors, the shapes, etc., of objects are really there. [...] Not only is thought in the organic world, but it develops there. But as there cannot be a General without Instances embodying it, so there cannot be thought without Signs”. (CP 4.551, 1906)

(VI) Finally, the information must be "local," since any observation is by definition local, i.e. direct rather inferred as in quantum entanglement.

3. Fisher information

Suppose that a system is specified by a parameter value *a,* and is observed so as to know *a*. For this purpose *N* data **y** are collected. The data depend on both *a* and a random component **x**. Data y are instantiations of the general law that governs the phenomenon. They are replicas or tokens that embody the information of the legisign (the probability law).

The fluctuations *x* in any one define a probability law *p(x)* that is a law of science describing the observed system. It is desired to know *p(x)* as well. The data **y** vary randomly from one set of observations to another according to some relation such as y=a+x (additive case).

Then for any fixed *a* there are randomly many possible sets of data y and, therefore, many possible estimates of *a*. However, it is easily shown that, for any such estimate that is unbiased (generally incorrect but with a correct average value), the resulting mean-squared error e^2 in the estimate obeys the inequality

$$e^2 I \geq 1.$$

This is called the "Cramer-Rao inequality." Here I is an information called the "Fisher information." It obeys

$$I = 4\int dx \left(\frac{dq}{dx}\right)^2, \; p(x) \equiv q^2(x),$$

where *q(x)* is the *amplitude* of *p(x)*. The C-R inequality shows that the smallest value of e^2 is *1/I*, so that the error and the information obey a complementary relation -- if one is very small the other tends to be large. Thus, the size of information I is basic to how well the unknown parameter can ever be known.

It is this I that grounds the hypothesis formation that is a fundamental step in any inquiry.

The C-R inequality has many applications to scientific laws in and of itself. It has been used to derive the Heisenberg uncertainty principle, an uncertainty principle of population biology, and a decision rule on predicting population cataclysms.

In a case of $N=1$ datum y, with $y=a+x$, and where the noise x is known to have zero mean, the optimum estimate of $a = y$, is the datum, by definition. This is called the "maximum likelihood (ML) estimate." In general, the ML estimate is accepted as a "good" estimate of the parameter.

But, information I has a further role to play, as the key *ingredient in estimating the scientific law p(x) itself*. Note that I is expressed above as simply a sum of squares. This turns out to provide the key to finding *p(x)*.

4. Extreme physical information (EPI)

The unknown effect *p(x)* under observation, and the observation *per se*, form what is called a "learning channel", which can be summarized as a transmission of information from Object through the Sign to the Interpretant (0-S-I). The learning is about parameter value a, and is ultimately defined by two quantities of information: (i) The amount that pre-exists at, or is 'bound to,' the source effect, denoted as the amount $J \equiv J(a)$. And (ii), the amount that is received by the observer, denoted as the amount $I(a)$. The flow of information in the learning channel defines an information channel

$$J \rightarrow I.$$

Semiotically, these can be translated as:

(1) J is the information bound to the dynamic object

(2) the arrow → is the sign as a medium for transmitting such information.

(3) I is the information present in the interpretant

The higher the level of information I is in the data the greater is the potential amount learned about a. As will be seen, this holds for *p(x)* as well. This is so because a higher level of information I allows for a better hypothesis, paving the way for the inquiry.

What can be learned about the relative sizes of I and J? Answering this question will lead to an epistemic basis for deriving the form of $p(x)$ and, hence, all physics (and science).

5. Two variational principles

We reasoned in Axiom (IV) that the arbitrary measure of stability $f(I,J)$ must remain stable for a coherent universe to exist. Now, we can always represent $f(I,J)$ as some other function $g(I-J, I/J)$ of the information changes $I-J$, I/J. For example, if $f(I,J) = sqrt(IJ)$ then $g(I-J,I/J) = (I-J)sqrt(I/J)/((I/J) - 1)$. Therefore, perturbing f is equivalent to perturbing g.

Note the derivative chain rule identity

$$var\, f = (df/d(I-J))\, var(I-J) + (df/d(I/J))var(I/J)$$

where *var* means variation and d denotes a partial derivative. Hence, requiring that $var\, f = 0$ is equivalent to requiring that the right-hand side be zero. But the two right-side terms express independent degrees of freedom of the problem and function f is arbitrary. Therefore each must be zero, and since f is arbitrary its indicated derivatives are arbitrary. Therefore the only possibility is that

$$var(I-J)=0 \text{ and } var(I/J)=0.$$

6. EPI Variational principle EPI1 and Zero-principle EPI2

The solution to the left-side equation preceding is simply

$$I-J=extremum \qquad \text{EPI1}$$

The extremum is attained by the form of $p(x)$. This defines a problem called the EPI variational principle. By comparison, the right-side equation cannot also be a variational principle since that would overconstrain the problem. Therefore its solution is simply

$$I/J=\kappa=constant,$$

where κ is to be found from other prior knowledge. Its value varies with the level of prior knowledge of the source effect. In all cases it is found that $0\leq\kappa\leq1$. In summary,

$$I-\kappa J = 0,\ \ 0\leq\kappa\leq1 \qquad \text{EPI2.}$$

This means that the observer cannot gain more information than pre-exists in the effect,

$$I\leq J$$

and is called the EPI zero-principle. The constant κ defines the information efficiency of the system.

Since $\kappa\leq1$, the best the observer can do is achieve I maximally close to J, meaning that the extremum in principle EPI1 is usually a minimum,

$$I-J = minimum.$$

This turns out to hold for problems with real coordinates x.

7. Local information property

Recall our search for a "local" information measure. The defining integral for I depends only upon local slope values of the law $p(x)$. Thus, any one large slope value can dominate the answer I regardless of the rest of the curve. This makes I a local information measure (the Shannon entropy measure, by comparison, is well known to be global).

8. Scope of solutions

What are the two informations I, J in the EPI principle? Information I is, regardless of source effect, of the above mathematical form. It just characterizes data. By comparison, the source information J characterizes the particular effect. Thus, for any given problem, it is easy to find I, but how is J found?

9. Finding the source information *J*

Just as there is no rote way of deriving all laws of science, there is no unique rote way of deriving information J. What EPI contributes is an overall framework for this quest. A further contribution is reduction of the search space to but three fundamentally different ways of finding J. These depend upon the type of prior knowledge that is at hand. These correspondingly give rise to three levels of accuracy in the solution. In descending order of accuracy, they are as follows.

(A) Exact, unitary scenarios

Cases where there is an observable space that is unitary (say, via Fourier transform) to data space allow for complete recovery of the source information, i.e. $I=J$, and a completely accurate estimate of the unknown law.

Norms of the sum-of-squares form of Fisher I above are fundamental to physics. They are called L^2 forms, and have the property of being length-preserving. Hence they are invariant to unitary transform U. In fact, many real observation spaces y have conjugate spaces that are unitary to them and likewise real (observable). For example, the two observable spaces are of space-time and momentum-energy, respectively, and are connected by a unitary Fourier transform. This is the well-known case, e.g., in quantum mechanics.

In these unitary scenarios, by the length-preserving property, $J=I$ so that the zero-property of EPI holds. Also, that the EPI variational principle itself holds. Indeed, they both hold independently, giving generally different (but consistent) solutions $q(x)$. Examples of such EPI solutions are the Klein-Gordon and Dirac equations of quantum mechanics; and Newton's Second law $f=ma$ and the Virial theorem in classical mechanics.

(B) Inexact, classical scenarios

Obviously, exact (type A) solutions are preferred. However, these require the existence of a unitary space. What, then, can be done if a unitary space is not known? Without the space, the condition $J=I$ of zero loss of information is no longer true. Hence, $\kappa<1$ and an inexact solution is obtained.

Such solutions, in fact, describe classical levels of physics, for example gravitation and electromagnetics. Here, J must be solved for, by simultaneous solution of the two EPI conditions. The supposition is that the lower level of information now disallows the knowledge of two distinct solutions, so that they are effectively "blurred together" into one composite law approximating both. For brevity, this is called a self-consistent EPI solution.

In order to obtain such a common solution some prior knowledge must be at hand about $q(x)$. This is generally in the form of an invariance principle, such as continuity of flow. Although the output laws are approximations, they are very good ones. Remarkably, the efficiency variable κ is found to be exactly 1/2 in these cases, rather small considering how good the approximations are.

(C) Empirical scenarios

The lowest level down in accuracy ensues in scenarios where *there is no ground truth at hand.* Knowledge of the physics of the source is completely lacking. There is no model for J, and neither κ nor J can be solved for. The only knowledge there is, is of an indirect nature: mean data values F_m, m=1,...,M. This occurs, e.g., in econophysics where the "technical viewpoint" of investment assumes that price data alone suffice as prior knowledge (effective invariants). Or, in statistical mechanics, the invariants are extrinsic measurements of mean values.

In these cases, where a precise information J is not known, it can be replaced with what is known, namely, a sum of constraint terms. The EPI variational principle thereby becomes,

$$I - J = minimum, \text{ where } J = \sum_m \lambda_n [\int dx f_m(x) p(x) - F_m, \quad p(x) = q^2(x).$$

The constants λ_m are called 'undetermined multipliers.' These are found by demanding consistency of the constraint integrals with their corresponding data values F_m. This is a generally nonlinear problem, but easy enough to numerically solve, for example by Newton-Raphson methods. However there is an essential departure in the meaning of these solutions from those preceding:

The extremum is still a minimum. However, the bracketed quantities are now all zero at solution. Therefore, J is fixed at value zero. Then only quantity I is minimized, and it is no longer true that $I \sim J$ at solution. The minimized value of I must cause a poor estimate of a, and this is mirrored in poor accuracy for the acquired law $p(x)$ itself. In fact since I measures the gradient content in $p(x)$, its output shape will merely be as smooth as is possible.

10. Resulting information game

We found in the preceding that EPI solutions tend to give maximally spread-out or blurred $q(x)$ or $p(x)$ curves. This blurring effect also implies that an act of observing is effectively a move in a mathematical game with nature. This game aspect of EPI is discussed in the next few sections.

Minimax nature of solution

In comparison with the above minimizing tendency due to blurring, the general form of I that is used represents a state of the system that maximizes the information, as if it arose out of independent data. Or conversely, for any fixed state of blur, I decreases with increased correlation of the data. Picture, in this light, values of I in a two-dimensional space of correlation value ρ (vertical axis) and degree of blur (horizontal axis). Coordinate ρ increases vertically and the blur coordinate increases to the right. The EPI solution q(x) occupies a point in this space on the horizontal axis, since this is where $\rho=0$. The finite degree of blur then places the solution point on the horizontal axis and somewhere to the right of the origin (defining the state of blur). The exact position of this solution point is determined by the nature of the invariance principle that is used in EPI.

Saddlepoint property

In cases (C), we found that the form of *J* is fixed by empirical data. Since these have random components, the resulting EPI outputs cannot have universal validity.

Let us test the kind of extreme value in *I* that exists at the solution point in this space. In particular we are interested in the possibility of a saddlepoint that would be where *I* is locally maximized in one direction but minimized in the other. Consider, in this light, excursions toward the solution point from a nearby point to its left and above. As the test point moves to the right (toward the solution) the blur increases and, so, *I* decreases. On the other hand, as the test point moves downward (still toward the solution) correlation decreases so that *I* increases. Therefore, the EPI solution point is a maximum value in one direction (vertical) and a minimum in the other (horizontal). Hence it is a saddlepoint solution. The particular saddlepoint is fixed by the nature of the EPI solution.

Game aspect of EPI solution

A saddlepoint solution also characterizes the solution to a mathematical, fixed-point, zero-sum game (Frieden and Soffer, 1995) between two protagonists. Here one player selects a horizontal coordinate value as its "move," and the other a vertical coordinate. The game has information *I* as the prize. Hence, each player tries to maximize his level of *I,* and this is at the expense of the other since it is a zero-sum game.

Owing to the fixed nature of the EPI invariance principle in use, the game is "fixed point," i.e. the solution point is always the same, independent of which player makes the first "move."

Since information is the prize, this is called the "information game" or "knowledge game."

11. Information demon

A useful mnemonic device is to regard the enforcer of correlation as the observer, and the enforcer of the variational principle *I=minimum*, which blurs the amplitude function *q(x)*, as nature in the guise of an "information demon."[3]

In the pragmatic inquiry, our observer is the logical interpretant – a self-correcting entity (an intelligent mind) that enforces the representation of the dynamic object by the sign. The dynamic object, as the information demon, remains always out of the sign and changes its shape continuously to escape from a complete symbolic representation. In the Existential Graphs, the role of the dynamic object is played by the Grapheus, which is continuously adding new graphs to the sheet of assertion, while the Graphist tries to capture the pattern of its moves by breaking the continuum into separate steps.

By this picture, the observer (the interpreter), initiates the "play" by putting a question to the demon (the dynamic object), in the form of a request for data. This is the beginning of the semiotic inquiry, since data can only be expressed by signs. By our axioms, all players in the universe want maximum information. For this purpose, the observer collects the data independently, interpreting the signs that represent some aspect of the bound information held by the demon. But any information that is gained by the observer is at the expense the dynamic object, since any observation randomly perturbs its object and, hence, introduces disorder into it. The ultimate cause of such perturbation is of course due to the Heisenberg

[3] This is not the Maxwell demon who, by contrast, tries to be purely helpful. Our information demon tries to degrade the answer.

uncertainty principle. The final result is that, while the sign is turned into a symbol that grows and becomes ever more abstract and habitual, it also loses contact with its source of information.

It all happens as if the demon/dynamic object wanted to *minimize* his expenditure of information, escaping from complete symbolization. For this purpose, the demon's move is to inject an amount of blur into the output law of the symbol. As we saw, the payoff point of the game is the EPI solution.

12. Applying the knowledge game in communication

Peirce's idea of communication is closely linked to rhetoric and methodeutic, which are the third branch of semeiotic. It embraces the pragmatic ideal of a community of logical interpretants welded in a collective mind – the *commens* or co-mind – that, starting from a common ground of hypothesis, would develop towards a better understanding of its object of inquiry (the dynamic object that holds the information to be found out). As Peirce states, "indeed, two minds in communication are, in so far, 'at one,' that is, are properly one mind in that part of them" (EP 2: 389). These minds do not have to be conscious either. They can be quasi-minds, that is, anything capable of being affected by a sign in a way to produce an interpretant. How does this scheme fit to what we have discussed so far?

a) The **dynamic object** is the utterer of the form to be communicated. Its information is an upper bound that determines (constrains) the sign's ability to represent.

b) The **sign** the medium of communication of this form.

c) The effect of communication is the **interpretant** (the interpreter of the formed communicated) which can be emotional, energetic or logical. Only the logical interpretant is capable of self-control, that is, it conducts the process of semiosis towards the growth of information. This is accomplished by symbolization.

d) The communicating logical interpretants (minds or quasi-minds welded as *commens*) can be of two distinct moments of oneself (in the case of a introspective reflection, when the process of semiosis happens between two distinct states of information of the same self), or can be of two or more different selves (two persons, for instance, but maybe two specimens of dolphins or a group of apes) involved in a pragmatic inquiry.

13. An example

Let's suppose A wants to share an idea with B. To accomplish its goal, A must express his idea through a channel and use a message (usually strings of coded signs in the form of sounds, letters etc, but sometimes something more iconic such as a painting, a play or any work of art).

The real utterer is neither A nor B, but the form of the idea to be communicated – it's information. That is the dynamic object of this semiosis that plays the role of a demon. As the EPI theory explains, there is a natural tendency that the message will be drawn in an ocean of entropy if A and B do not continuously rescue it from its fate by elaborating its information. To accomplish this, A and B must already have some previous common information in their minds, gained by what Peirce describes as collateral experience: if A wants to tell B an idea of a monster, for instance, they both must have some common understanding about what it is like to be a monster (some bad creature, furred skin, long teeth etc).

Now, we may consider the idea in A's mind as the unknown parameter that B is supposed to acknowledge. Since they share a common ground, B is able to make hypothesis during the process of interpretation. This is an EPI supposition about the parameter to be communicated.

The message A sends (for instance, words, mimics, facial expressions etc) is some collection of fluctuations obeying some probability law that "represents" the idea in B's mind. The first thing B has to do is to find out the correct estimator that will show all the fluctuations you are getting as a coherent process. When that happens, they are "welded" or in other word, they are communicating.

The demon will try to avoid the success putting noise and blurring the probability law of the message. By noise we mean pure qualities without pattern. Actually, any expression made by B is nothing but a collection of qualitative fluctuations that gains meaning only during the process of interpretation. The role of the demon is always try to produce absolute new fluctuation that will blur the information being transmitted.

Nevertheless, the payoff of the game is usually positive for the communicating minds side sincewhenever they assume a new hypothesis about the meaning of the dynamic object, they increase the amount of information either by knowing better the probability law that maximizes the communication of the idea or else by ruling out possibilities that would lead you to "dead ends" in the process of communication**.**

The game will be a zigzag between the "clear" idea A and B want to share and the point of complete lack of information the demon tries to impose. This zigzag has a resultant arrow that works as a vector towards complete understanding that, if taken by an ideal commens within an ideal period of time, would be the final result of the communicative process: the ultimate logical interpretant, in which case the immediate object of the whole communicative sign would be the very percept that both A and B experience while sharing the communicated idea.

14. Conclusion

In What Pragmatism Is (1905, EP2: 331), Peirce writes that we should

> (...) not overlook the fact that the pragmaticist maxim says nothing of single experiments or of single experimental phenomena (for what is conditionally true in future can hardly be singular), but only speaks of general kinds of experimental phenomena. Its adherent does not shrink from speaking of general objects as real, since whatever is true represents a real one. Now the laws of nature are true.

In fact, following the pragmaticist maxim, EPI is a principle that allows an observer to reconstruct the general kinds of experimental phenomena (the laws of nature) out of simple rules. These rules stem from the fact that any such law has both a mathematical nature A and an observational nature B. The combined effect AB represents the participatory nature of physics (something A. Einstein never accepted, but that seems to be in accordance with Peirce's synechism). An observation usually perturbs the thing observed. Hence assume that system AB is perturbed. Simple ignorance gives an effectively random component x to AB, whose probability law p(x) is also perturbed, and also represents the law of nature to be reconstructed. The axiom that AB must be stable to perturbation gives the EPI principle I - J = extremum, I = kJ, from which p(x) may be reconstructed (or estimated).

The reconstructions follow three levels of accuracy, depending upon the nature of the prior knowledge of the effect that is under observation: Level (A) has perfect accuracy, and follows from knowledge of a unitary transform space to data space. Level (B) has high, but finite, accuracy. It gives classical physics, since it ignores quantum effects. This follows from knowledge of a prior invariance principle such as continuity of flow. Level (C) has the lowest level of accuracy, following from mere empirical knowledge of data from the law. All the major statistical laws of physics, and many of biology, chemistry, economics and medicine have been so derived by past use of EPI. These contain both previously known, and new, laws.

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References

FRIEDEN, Roy. Science from Fisher Information, 2nd ed. Cambridge Univ. Press, UK, 2004 (2000).

FRIEDEN, Roy. and SOFFER, B.H., “Lagrangians of physics and the game of Fisher-information transfer,” Phys. Rev. E 52, 2274-2286 (1995).

FRIEDEN, B.R. Frieden and GATENBY, R.A., eds, Exploratory Data Analysis using Fisher Information. Springer-Verlag, London, 2007.

PEIRCE, Charles S. Collected Papers of Charles Sanders Peirce. 8 vs, P. Weiss, C. Hartshorne and A.W. Burks eds, Cambridge, Mass.: Harvard University Press,1931-58.

______. The Essential Peirce*, 2*, Peirce Edition Project. Bloomington: Indiana University Press, 1998.