Journal of International Scientific Publications:
Materials, Methods & Technologies, Volume 6, Part 1

THEORIES OF COMPLEX SYSTEMS IN PSYCHOLOGY: PRESENTATION OF A NEW PARADIGM

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Abstract

This paper presents a paradigm of the new dynamic characteristics of Nature according to the importance of the effect of the elements that compose it. This paradigm is based on the paradigm of complex systems. These have been considered in numerous works in many disciplines. The heuristic significance of complex systems is high. The paradigm of complex systems supports the idea according to which a system oscillates between instability and organization, which leads, by emergence and self-organization, to a new system that is highly sustainable and adaptable. This brings us however to the crucial issue of the high intrinsic variability of the determinants which take part in the evolution of the system. These aspects are discussed in the research note as are the future and epistemological implications.

Key words: Non-linear complex systems, complexity, adaptation, Nature, variability.

1. INTRODUCTION

We must distinguish a complicated system from a complex system. The former can be interpreted through a Cartesian cutting into small sections in order to make it easier to understand, while the latter necessarily involves a comprehensive approach to Nature. This distinction is based on the work of the Nobel Prize winner in physics, P.W. Anderson (1972).

According to author (Hassas, 2003, p.13), a non-linear complex system is: "the set of variables allowing us to characterize its state and the functions expressing their evolution over time. When these functions are not linear, the system is said to be non-linear dynamic. In adaptive complex systems, the functions expressing the evolution of the system over time are indeed non-linear due to the non-trivial interactions (retroactions for example) that characterize these systems. Moreover, when the transitions from a state S of the system to state St+1 are deterministic (i.e. not probabilistic), the system is characterized by a deterministic non-linear dynamic."

In epistemological terms, the position of Karl Popper (1973, *1995*) is based on the idea according to which the examination of a rational/logical approach must be part of a justification of a plausible theoretical system. In this respect, "induction" which is the feature of all explanatory approaches of empirical and observable facts, can in and of itself cause the researcher to adopt an erroneous posture. As a reminder, *induction* is based on:

1) The reproduction of a given phenomenon (i.e. the same causes generate the same effects);

2) A law that is valid for an identified object of study and for all the elements that compose it is valid for all of the elements taken individually;

3) The law that prevails for one case will prevail for all analogous cases.

In an *inductive* approach, it is the observation of a unique fact that calls for the construction of new knowledge. That is why it is the observation of the particular fact that produces the theory. We can also speak of an empirical-deductive approach. This is where we find (in particular) a "classic" factorial analysis in which the model is established after the fact. In this case, the power of the statistical tool, such as confirmatory factor analysis, consolidates the approach. But researchers must not be content with this. A theory that is accredited by itself or by the power of a method cannot be considered satisfactory. We have the idea that Research must constantly provide "explanatory content of the things of Nature in excess" i.e. provide new theories in the revisable sense of the term.

The disciplines must therefore provide plausible explanations until there is proof of the contrary. This is the real challenge by virtue of the fact that a theory must be "*good*" until another one is judged "*better*" and supplants it.

In the *deductive* approach, the researcher initially establishes a working hypothesis which is based on a model, materializes the hypothesis through a protocol and tests it so that the initial model can be improved, replaced or rejected.

It therefore pushes me to go forward and to experiment with new models which – by Nature we hope – will become outdated.

The theory of complex systems is well suited for addressing some of the issues of explaining the world through a comprehensive understanding of interconnected phenomena.

As a reminder, the understanding of natural things involves a minimal logic which is expressed in the followed manner:

Observed effect = Real effect + Bias + Random error

This logic is valid in an ecological context for an evaluation "at rest" of the characterization of the study variables.

2. PRESENTATION OF A DYNAMIC PARADIGM

From a dynamic perspective this time, we consider that the entropy of the system increases with time (t) such that ϵ_t reflects the random and continual changes (positive or negative) of an iterative series. In this iterative order, we use a model with the hypothesis that a score obtained at $t4$ determined by a score obtained at $t3$, itself determined by the one obtained at $t2$, and so on. Thus, each current score (coefficient of auto-regression φ) is the result of a weighted sum of scores obtained previously, presented in the form of coefficients (with calculation of the moving average). The iterative series (y_t) follows the *Auto-Regressive Integrated Moving Average* (ARIMA) procedure of Box & Jenkins (1976) which aims to identify the function:

$y_t = f(y_{t-1})$

Logically, the current score is subject to the following equation:

$y_t = \varphi\, y_{t-1} + \epsilon_t$

With consideration of the total error Δ (the accuracy of the measurement or uncertainty [$\Delta 1$]; the statistical dispersion [$\Delta 2$]; and the systematic error [$\Delta 3$]):

$\Delta = \Delta 1 + \Delta 2 + \Delta 3$

The effect observed or resultant called e* (along with its uncertainty calculation) of an iterative series will obey the following function for a non-stationary system:

$$f(y_t) = (\phi y_{t-1} + \phi \epsilon_{t-1} + \epsilon_t + \Delta)$$

However, this presentation is incomplete because as such, we consider that y_t of a non-stationary system in an ecological context undergoes the uncontrollable and unpredictable impacts resulting from the self-organization at time *t*. Does this mean that "all other things being equal" the variables that impact it are equivalent? I don't think so. So it is necessary to improve the equation a little by introducing a size effect. Here of course we accept that the probability of appearance of an event at *t* depends not just on an iterative series but also on the weight of each of the elements that composes it.

In this case we introduce an indicator to evaluate the importance of the effect. In other words, to gauge the force of this difference which is applied to x elements. The contingency coefficient Phi (ϕ) is used for this. It is used to measure the size of the differences between 2 proportions ($\sqrt{(X^2/n)}$, n corresponds to the intensity and/or the frequency of elements taken 2 by 2 of a $\phi\ \epsilon_{t-1}$ and ϵ_t subject to entropy.

As a reminder, the contingency coefficient Phi (ϕ) is calculated using a contingency table that oscillates between +1 and -1 (0 corresponds to the absence of difference between the 2 elements or events). It is usual to consider the effect weak at 0.1, average at 0.25 and strong at 0.45 (See Guéguen, Lourel & Pascual, 2007). The coefficient Phi s expressed as follows:

$$\Phi = \frac{(A \times D) - (B \times C)}{\sqrt{E \times F \times G \times H}}$$

Structure of the contingency table in the calculation of the coefficient Phi (ϕ)

Variable 2 / Variable 1	Modality 1	Modality 2	Total
Modality 1	A	B	A+B = E
Modality 2	C	D	C+D = F
Total	A+C = G	B+D + H	

With a correction for the size of the effect of $\phi\ \epsilon_{t-1}$ and ϵ_t we can simplify the terms as follows:

If we accept an infinite number of hypotheses in a fixist state in which the base postulates are limited, we can present this as follows:

$$\sum e^* = (H^{\infty}) \times (A)$$

Keeping in mind that:

$f(y_t)$ est soumise y_{t-1} où ϕ est pondérée et insertion faite de Δ alors :

$$f(y_t) = (\phi y_{t-1} + \phi \epsilon_{t-1} + \epsilon_t + \Delta)$$

Above, a reminder of the equation before transformation. $\phi\ \epsilon_{t-1}$ and ϵ_t are corrected and weighted according to their effects. We thus obtain:

$$f(y_t) = (\phi y_{t-1} + \sum_{y_{t-1}\lfloor 1 \text{ et } \infty \rfloor}^{(\sqrt{\frac{X^2}{n}})} \phi \epsilon_{t-1} + \sum_{y_{t=1}}^{(\sqrt{\frac{X^2}{n}})} \epsilon_t + \Delta)$$

Thus, in a dynamic system in which the postulates are finite, the resultant e*can be simplified in the following manner:

$$f(e^*) = \frac{\sum e^* = (H^\infty) \times (\vec{A})}{\phi y_{t-1} + \sum_{y_{t-1}\lfloor 1 \text{ et } \infty \rfloor}^{(\sqrt{\frac{X^2}{n}})} \phi \epsilon_{t-1} + \sum_{y_{t=1}}^{(\sqrt{\frac{X^2}{n}})} \epsilon_t} + \Delta)$$

If we accept that in a dynamic system subject to entropy and in which the base postulates are included in a finite vectorial space, then the function is expressed in terms of covariants of which the covariant derivatives are identically *zero,* in accordance with the Einstein equations presented below.

Reminder of Einstein's equations

(Excerpt according to http://florenaud.free.fr/Cosmologique.php)

"In Einstein's equation, the parameter Λ is the cosmological constant

$$R_{\mu\nu} - \frac{1}{2} g_{\mu\nu} R - \Lambda g_{\mu\nu} = \frac{8\pi G}{c^4} T_{\mu\nu}$$

In this case, the left member represents the geometry of space-time. The right member brings in gravitation and the energy tensor. By placing the cosmological term at right, its meaning changes.

$$R_{\mu\nu} - \frac{1}{2} g_{\mu\nu} R = \frac{8\pi G}{c^4} T_{\mu\nu} + \Lambda g_{\mu\nu}$$

It now involves a form of energy that ordinary matter would not contain and which would be equivalent to an additional tensor.

$$T_{\mu\nu}^{(\Lambda)} = \frac{\Lambda c^4}{8\pi G} g_{\mu\nu}$$

Based on this expression, we can calculate the volume density of energy

$$\rho_\Lambda c^2 = \frac{\Lambda c^4}{8\pi G}$$

And then the pressure

$$P_\Lambda = -\rho_\Lambda c^2 = -\frac{\Lambda c^4}{8\pi G}$$

On the macro level, it is now accepted that the Universe, a thing of Nature, shows a rate of expansion which is the combination of the density of energy and the pressure of the physical content that composes it. An equation of state (called w by convention), illustrates the relationship between pressure and energy. Thus for ordinary matter, the pressure is insignificant such that w = 0. On the micro level, it was demonstrated that the relativistic particles provide radiation that equals w = 1/3. But for a Universe in accelerated expansion, the most recent works show that it must contain a

component strictly less than – 1/3 in the equation of state. Whence the necessity of considering a so-called "cosmological constant" to predict the outcome of a Universe in accelerated expansion. This was introduced by Einstein in 1917 in all of the equations of general relativity (1915), and is written as "Λ" by convention. At the time, the author thought that the Universe was static. As has just been stated, the most recent works show that the Universe is in expansion and that a constant plays a role in what is called "vacuum energy." The equation of state associated with the cosmological constant is illustrated as additional matter such that w = – 1.

The human phenomenon and its behaviors are no exception. They are subject to the nomothetic laws of Nature. It has been demonstrated that they follow a clear series of events, in a complex system of non-linear order that oscillates between equilibrium and instability. Complexity leads to new properties based on self-organization at time *t*. With the correction made in our analysis for the degree of the effect of the variables that impact the resultant, the plausibility of an event at time *t* is still accelerated by a phenomenon of entropy that requires, and this is my point of view, the introduction of a hidden constant (Λ), but one that is omnipresent in the equation of state. In this respect, we propose an equation of state simplified as follows:

$$f(e_{\Lambda}^{*}) = \frac{\sum e^{*} = (H^{\infty}) \times (\vec{A})}{\phi y_{t-1} + \sum_{y_{t-1}]1 \text{ et } \infty]}^{(\sqrt{\frac{X^2}{n}})} \phi \epsilon_{t-1} + \sum_{y_{t=1}}^{(\sqrt{\frac{X^2}{n}})} \epsilon_{t}} + \Delta)$$

3. CONCLUSION

For these reasons, I think, an *allowable* paradigm must necessarily be based on a dynamic approach that excludes, de facto, the classic and *fixist* attempts at explanation of natural facts, including facts of an epistemological order. In our view, this is one of the main factors that make the theory of complex systems valuable. In this respect, our paradigm, if it is confirmed, will make it possible to take into account certain outcomes or new dynamic characteristics of Nature. These are universal elements that must be taken into account in all approaches to the dynamics of the laws of probability of a complex system, approached in a comprehensive manner. The heuristic significance that is offered by the paradigm of non-linear complex systems is high. The paradigm defended in this research note begins a response to the question of the materialization of the universal laws of Nature which all complex and adaptive systems obey. This leads us to the fundamental issue which is the epistemological break with the classic paradigmatic currents (often causal) involving natural – and also human – phenomena, in the meaning used by Teilhard de Chardin (1955). The stakes are crucial for the Sciences. For several years now, the notion of complexity has been under consideration in the Human Sciences, and it has led to the development of original paradigms. These have led to new approaches in inter-disciplinary research strategies, to which we hope make our own contribution, however small.

4. ACKNOWLEDGEMENT

The research is no financed.

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