

A Historical Record

For the Record: A Historical Record of My Work With Teams

Marcial Francisco Losada, Ph.D
Founder of Losada Line

In July 2013, the *American Psychologist* published an article by Brown et al. that was critical of my use of the Lorenz model to portray the interactive processes of teams. Although I am not fond of academic debate, as I have chosen instead to devote my time to help people in teams within organizations to live a better life, at this juncture I would like to take the opportunity to set the record straight. I have had unprecedented success in my 29 years working with teams. Being that this is the first criticism to appear in 15 years since my first paper, “The complex dynamics of high performance teams” was published in the journal *Mathematical and Computer Modelling* (1999), I decided to share this historical record that honors the memory of the great scientists who inspired and supported my work. Another important element in this decision is to let my clients know more about what made this work possible.

In support of my work with the Lorenz model and team interaction, I have constructed a table that highlights my work and contrasts it with that of my critics.

Data Comparison	Brown et al.	Marcial Losada
Number of observations supporting conclusions	Zero	626,235 observations on 2088 teams' diagnoses
Experience in dynamical analysis of team interaction	None	29 years
Effectiveness of the proposed model	No model is proposed	27% increase of productivity on average is expected if the model is practiced

Number of favorable citations in Google Scholar	28	2014
Support from leading psychologists in human interaction processes who had seen my data	None	<ul style="list-style-type: none"> • E. Burnstein, Research Center for Group Dynamics, University of Michigan • E. Schein, Sloan School of Management, MIT • J. Gottman, The Gottman Institute
Support from leading mathematicians in differential equations, modeling and nonlinear dynamics who had seen my data	None	<ul style="list-style-type: none"> • G.– C. Rota, MIT Mathematics Department, Norbert Wiener chair • N. Metropolis, Los Alamos National Laboratory
Recognition from higher education and government authorities who had seen my data	None	President of MIT, C. Vest, invites the Vice-president of the US, Al Gore, to visit my lab in Cambridge

1. The scientists that I cite saw my data, were well acquainted with my work and supported it. Conversely, Brown et al. never saw my data, nor were they at my labs in the United States; furthermore, they did not attend any of my workshops. They base their criticism on *a-priory* arguments that rely upon assumptions about the data.

2. Thousands of engineers with thorough knowledge of the differential equations used in my model were trained in my workshops. All of them, without a single exception, have nothing but appreciation for the power these simple differential equations have to represent their processes of interaction. Every team that goes through my workshops is diagnosed before the training using the

variables of my model. After each workshop, we diagnose the team again. Most teams go through 3 or 4 workshops, depending on the initial diagnosis. Consequently, we have compiled the world's largest database on the interactive processes of teams. These data confirm that the *Losada ratio* ($P/N=3$) separates medium from high performance teams. Brown et al. have neither presented any data to refute this fact, nor have they proposed any alternative model that can be tested.

3. Professor Eugene Burnstein was Director of the Research Center for Group Dynamics at the University of Michigan. I became part of this program while I was obtaining my doctorate in social and organizational psychology at Michigan. This center is considered one of the world's top training programs in group dynamics. When I started the lab on team interaction in Ann Arbor, Burnstein sent his doctoral students each year to visit the lab in order that they could observe first hand how the time series of the teams' coded behaviors (inquiry, advocacy, other-focus, self-focus, positive feedback, and negative feedback) were built second-by-second on a monitor we had installed outside the observation room. This was a first in the history of group dynamics. Many professors from different countries visited our lab and were amazed at what we were doing there. Burnstein used to say that this work, "was a credit to Michigan's Psychology Department."

4. Brown et al. affirm categorically that you cannot use differential equations with these time series. Capital markets time series, which are produced second-by-second, are analyzed daily with differential equations by financial experts. What is the structural difference in terms of continuity with my time series which are also gathered second-by-second? I am in a position to say that there is no difference, because I worked for five years in the capital markets modeling these data with differential equations. I also worked for several years doing similar work with the Index of Consumer Sentiment of the Economic Behavior Program at the University of Michigan. Furthermore, the United States government granted me US citizenship for this work at the request of the University of Michigan.

5. Ed Schein is professor of Organizational Psychology at the MIT Sloan School of Management. He is the founder of OD (Organizational Development). When Ed visited my lab in Cambridge and saw my work, he concluded that "all the faculty of MIT should come here." Other distinguished members of the MIT faculty came to the lab; among them was Arnaldo Hax. Arnaldo is an operations research engineer and world renowned expert in strategic planning who had a thorough knowledge of my work with teams. In fact, he was the first to encourage me to publish my findings. I also had the honor to receive Dr. Robert Solow at the lab, a Nobel Prize in Economics, expert in

mathematics and statistics and distinguished with the National Medal of Science by president Clinton. Dr. Solow praised the methodology I used in the analysis of team interactions.

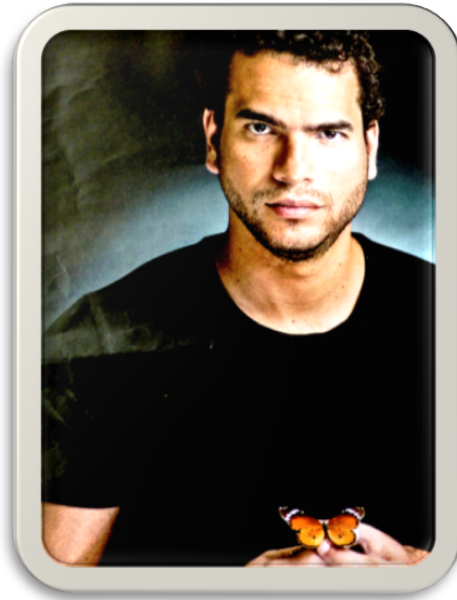
6. Professor John Gottman, who holds a Master's degree in mathematics from MIT and a Ph.D. in psychology from Wisconsin, visited my lab in Cambridge and after reviewing my work was amazed to see how his data coincided with mine. Dr. Gottman is a preeminent scientist in interaction processes in marriages and utilizes a similar methodology to the one I use with teams. Top marriages have a P/N ratio of about 5, as do my top performance teams. Marriages that end in divorce have P/N ratios below 1, as do my low performance teams. John invited me to give a conference at the University of Washington and recently asked me to join the institute that bears his name. He often cites my work in his international conferences as I do with his work.

7. Gian-Carlo Rota was the Norbert Wiener professor of Applied Mathematics at MIT's Mathematics Department. He was also a consultant to Los Alamos National Laboratory and to the Rand Corporation, a member of the National Academy of Sciences and vice-president of the American Mathematical Society. Gian-Carlo knew my work in depth and had great admiration for it. He was the one who sent my 1999 article, "The Complex Dynamics of High Performance Teams," to the journal *Mathematical and Computer Modeling* where it was accepted without a single modification. Gian-Carlo was a professor of differential equations and combinatorics, among other mathematical fields, and was considered one of the top mathematicians in the world. Gian-Carlo invited Dr. Nicholas Metropolis, a renowned physicist and mathematician from Los Alamos National Laboratory, a top center for nonlinear dynamics, to my lab in Cambridge. Dr. Metropolis developed the Monte-Carlo method together with John von Neumann and Stanislaw Ulam. He collaborated with Enrico Fermi and Edward Teller on the first nuclear reactors. After getting acquainted with my work, Dr. Metropolis invited me to deliver the "Director's Colloquium", a prestigious conference at Los Alamos National Laboratory and a "great honor" according to him. He told me that this conference was broadcast to the entire California university system. After the conference, there was only praise for my work.

8. Artur Avila won the Fields Medal in Mathematics in August 2014. This medal is considered to be equivalent to the Nobel Prize, since there is no Nobel Prize in mathematics. It is given every four years to the most outstanding mathematicians. Avila won the medal for his work on dynamical systems, especially chaotic systems of which the Lorenz model is prototypical. Avila got his Ph.D.

from the famous Instituto Nacional de Matemática Pura e Aplicada (IMPA) in Brazil and is now a director at the Centre National de la Recherche Scientifique, CNRS, in France.

Ed Lorenz is renowned for the title he gave to one of his papers, *Does the flap of a butterfly's wings in Brazil set off a tornado in Texas?* Here is the Brazilian Artur Avila, holding a butterfly in his hands after winning the Fields Medal.



Artur Avila, 2014 Fields Medal Winner

Instituto de Matemática Pura e Aplicada (IMPA), Brazil

Centre National de la Recherche Scientifique (CNRS), France

Dr. Avila has revolutionized the field of dynamical systems. He has published extensively on Lyapunov exponents and their spectra providing sufficient criteria for their use. The spectrum of Lyapunov exponents is utilized to describe the complex structure of the Lorenz model and other chaotic systems.

Dr. Claudio Chauke Nehme got his Ph.D. in System's Engineering, Computer Science, and Signal Processing at the prestigious COPPE, an interdisciplinary center at the Universidade Federal do Rio de Janeiro, for his outstanding work with Lyapunov exponents. Dr. Chauke and I have had fruitful exchanges on the nature and use of these exponents as well as on Poincaré sections and Poincaré maps, which facilitate the understanding of the Lorenz model by reducing its dimensionality. Dr.

Chauke assigns my 1999 paper, "The complex dynamics of high performance teams," published in *Mathematical and Computer Modelling*, as mandatory reading for his graduate students. He considers it an example of the application of mathematics to the complexity of human interaction, a view shared by professor Rota.

9. Those critical of my model maintain that the Lorenz model is a model of fluid dynamics that cannot be used to model emotions over time. First, the variables in my model are inquiry, advocacy, self-focus, other-focus, positive feedback and negative feedback, not human emotions. Secondly, these critics seem to miss the essence of this model: its universality and representational power. Lorenz himself was well aware of the generality of his model as he wrote in his book "The Essence of Chaos" (1993). Further, Artur Avila found the abstract mathematical structure that explains the universality and representational power of this model, as well as other chaotic systems. The following three applications of the Lorenz model will illustrate the range of its representational power.

a. At MIT, Diana Dabby wrote her doctoral dissertation in electrical engineering and computer science using the Lorenz model to create musical variations of Bach and Bartók among others. Diana is also a concert pianist and composer who has performed at Carnegie Hall. Having myself listened to Dr. Dabby's variations, I find it difficult to decide which piece is more beautiful, the original or the variation produced by the Lorenz model; a dilemma also faced by professional musicians who have listened to these variations. The representational power of the Lorenz model is such that it manages to capture the essence of Bach's music with the simplest of differential equations. One could say that Lorenz has managed to resurrect Bach's composing genius. Dr. Dabby has noted that you can even create appealing mixes of Bach and Bartók music using the Lorenz model. Furthermore, she says that music is just an example, because music is merely one symbolic language out of many others. By way of example, a schematic representation of a dance sequence in ballet is a symbolic language.

b. In a second doctoral dissertation, Joshua Stuart at the Computer Science Department of the University of Colorado-Boulder, supervised by professor Elizabeth Bradley (Ph.D. in electrical engineering and computer science from MIT), used the Lorenz model to create variations on choreographic sequences, such as those of Ballanchine. The coding system we use for the variables in my model is a symbolic language that could be extended to the coding of sequences of nonverbal expressions associated with those variables.

c. A third doctoral dissertation was written by Geralda Paulista, under the supervision of professor Gregorio Varvakis (Ph.D. in mechanical engineering), at the Universidade Federal do Santa Catarina in Brazil. In this thesis, Dr. Paulista coded both verbal and nonverbal expressions of the variable positivity-negativity in my model. Her data confirmed my data. This work became prominent when the prestigious journal *Science* published an October 2010 article showing that the understanding of nonverbal cues is a critical factor in team performance. In fact, Dr. Paulista herself trains our teams in nonverbal expression using my model.

Brown et al. emphasize that differential equations can only model continuous data; this is generally true; however, the differential equations of the Lorenz model are exceptional in that they can capture and model a variety of phenomena, even discrete data. Despite the generally continuous nature of the data used in Lorenz's differential equations, even data that are characteristically discrete can be modeled utilizing Lorenz's equations, as noted in the three applications above. Music is made of discrete notes that are separated by rests. Notes and rests configure a musical phrase. Artur Schnabel, the famous pianist, once was asked: What is the difference between you and other great pianists? He answered: "We all play the same notes, but we don't play the same silences." Positions in ballet sequences are also discrete. And so are the codes we use to capture interactive behaviors in teams, be these verbal or nonverbal. All these events are discrete; nonetheless, they are all captured by the Lorenz model. Notes, positions, and behavioral codes are like pearls on a string. The string is provided by the differential equations of the Lorenz model. The string is continuous and can take many shapes, from a downward spiral to a butterfly. Thus the pearls (data) can be arranged following these patterns. Discreteness and continuity are harmoniously integrated. One cannot but wonder at the power and elegance of the Lorenz model. How can such simple differential equations model such a wide spectrum of phenomena?

10. The president of MIT, Dr. Charles Vest, was a distinguished professor of mechanical engineering at the University of Michigan where I met him. He was a member of an interdisciplinary team that I headed at the time. One day, Al Gore asked him what was new at MIT. Dr. Vest replied that he should visit MIT's Media Lab as well as my laboratory in Cambridge where "revolutionary work was done with teams." This was how the Vice-president of the United States came to my lab accompanied by a Ph.D. in engineering from MIT who at the end of the presentation told me "You should write a book about this; it's fascinating." Al Gore enthusiastically assented to his remark.

Some might ask why I did not answer the critiques of Brown et al. in the *American Psychologist*. The reason is very simple: I cannot objectively answer criticisms that are not based on data. In science, if you don't have data you don't have anything. There are two beautiful mathematical theories in physics, supersymmetry and string theory, which are not yet fully accepted because there is no data to support them. Even if my critics had gathered the necessary data to refute my

findings, I lacked the time to prepare a proper response. At the time, I was successfully using my model to work with the copper industry in my country. This work helps to build schools, hospitals and roads, in addition to making the miners' life more plentiful. Furthermore, the version of the model (version 1.0) that Brown et al. criticized is now obsolete. It was developed 18 years ago, in 1996, and published in 1999.

As our database grew in parallel with our experience in working with teams, so did the representational power of our model. We currently utilize version 5.0 to train our clients. We have defined the boundary conditions of the model ($18 \leq c \leq 33$, for $c = 18, 19, \dots, 33$), where c is connectivity. These boundary conditions make my model a special case of the Lorenz model. We use the Lorenz model within these boundary conditions as a representation of symmetry and lack of symmetry in two of our bivariate variables: inquiry vs. advocacy and other-focus vs. self-focus. The model portrays asymmetry towards self-focus and advocacy in the range ($18 \leq c \leq 20$) which corresponds to low performance teams. It portrays partial asymmetry with prevalence of self-focus and advocacy, but some inquiry and other-focus, in the range ($21 \leq c \leq 24$) that corresponds to medium performance teams. It portrays symmetry in these bivariate variables in the range ($25 \leq c \leq 33$), which corresponds to high performance teams. That is, high performance teams are able to keep a dynamic balance between their self-interest and the interests of others as well as between advocating for their own point of view and asking about others' point of view. This threefold representation of symmetry clearly demarcates low, medium and high performance in teams and is unequivocally supported by our data.

The word symmetry, in its Greek root, expresses balance, harmony and proportion. This is how it manifests itself in our most treasured values: truth (what I say must correspond with reality), beauty (balance and harmony of parts), and justice (evenhandedness). But symmetry has a hidden face that hides a deeper truth. This is the face that Évariste Galois saw when he gave us the legacy of group theory, the mathematical foundation of symmetry, before dying in a duel when he was only twenty-one. Then other great mathematicians, like Felix Klein, Sophus Lie, Hermann Weyl and Emmy Noether, increasingly showed us the beauty and power of this deeper truth. Physics managed to reach the pinnacle of science because it understood the power of this symmetry. The standard model of particle physics can be represented by three symmetric groups: $U(1) \times SU(2) \times SU(3)$. Symmetry is defined mathematically as "invariance under transformations." Doesn't the power of the Lorenz model reside in its ability to represent symmetry? Was not Diana Dabby successful in creating musical variations because the Lorenz model is invariant under transformations, as it keeps the essence of the original music (invariance) and creates variations using slight changes in the initial conditions (transformations)? Does not the Lorenz model capture the complexity of human interaction because it can represent the symmetry or lack of symmetry in these interactions? Phil Anderson, a Nobel laureate in physics, famously said: "It is only slightly

overstating the case to say that physics is the study of symmetry.” Would it be overstating the case to say that psychology would greatly advance if we learn to use the power of symmetry?

In the new version of the model, we also use the constants a and b as external and internal characteristics that all team members face. Parameter a represents organizational resistance to change (what we call “organizational viscosity”), and parameter b represents the negativity bias. Most importantly, according to Dr. Avila’s findings, we now view the model as a universal model. This means the model is not bound to any specific content. Thus we can model a variety of areas such as finance, negotiation and optimization using the generalized version (version 4.0). The earlier version of the model was retired from the *American Psychologist* upon the request of Barbara Fredrickson. However, this earlier version has not been retired from *Mathematical and Computer Modelling*, where it was sent and supported by professor Rota. The advancements with this model were not published because I am not in academia. Since I work as a consultant, they were applied to my work with teams.

The first lesson I learned at Michigan was that you need data to support your theories. Theories without data have only a guiding value. In his Nobel lecture, Max Planck said “numbers decide.” To play at science’s table you need special kinds of chips. These chips are data. I have 600 chips on the table with a value of one thousand each, gathered over 29 years of working with teams. Day after day, I keep on gathering data in all my workshops because the foundation of all my work is data. My stack of chips keeps growing. Conversely, since no data was presented in Brown et al. critique, not a single chip was put on the table.

Did Brown et al. raise generative questions in their article? Indeed they had. Let me point out a few. They asked what was the meaning of parameters a and b . I found the psychological content of a and b in version 2.0 (2006) of my model before they wrote their article. Nonetheless, I already provided the answer in this document. They questioned the validity of finding the critical ratio, $P/N=2.9013$, using the Lorenz model. I agree with them on this point. This is not the best way to find the ratio, as it is not based on data. The best way is to generate a large data set and see what the ratio is empirically. I did this and found that the critical P/N ratio is 3. Nonetheless, if you increase the “viscosity” parameter in the model by 10% (i.e., you increase parameter a from 10 to 11), then the critical ratio you get is exactly 3. Actually, most organizations we observe have a viscosity level above 10; however, these data were not available at the time. Brown et al. criticized the upper limit of the P/N ratio that we proposed using the Lorenz model. Fredrickson and I thought that the ratio could be 11.6. However, the most current data shows that the best team Dr. Paulista and I have trained so far reached a $P/N=5.71$, and this is after 6 months of training. In light of this finding, I no longer postulate the upper limit of the P/N ratio to be 11.6. Consequently, the upper limit most likely lies around $P/N=6$. Do we know if performance deteriorates if the ratio is

above 6? No, we don't, since we haven't found a single team that goes beyond 5.71. No data, no knowledge.

In science, as in life, we must learn from each other. Science is not a 100-meter dash, in which the best runner prevails. It is rather a long relay race, where one carries the baton but for a time doing one's best. In so doing one must not lose sight of two things: that someone else passed the baton to us and that we must in turn pass the baton to the next runner.

The Lorenz model is emblematic of such a relay race. I have highlighted just a few of the runners cited in this document for the diversity of their applications. The run starts with Ed Lorenz in 1963 when he modeled convection in the atmosphere. In 1995, Dabby took the baton extending the work of Lorenz to the generation of musical variations. In 1996, I further extended the model to interaction processes in teams. Stuart extended the model in 1997 to the generation of choreographic sequences. In 2009, Paulista extended the model to both verbal and nonverbal expressions that correspond to the variable positivity-negativity in my model. In 2014, Avila reaches farther than anyone by finding the abstract mathematical structure that explains the universality and representational power of this model as well as other chaotic systems. For this extraordinary accomplishment he received the Fields Medal, the highest honor in mathematics. However, we must not forget the first runner, Ed Lorenz, to whose memory I dedicate this historical record.



Ed Lorenz (1917-2008)

Brasília, Brazil
December, 2014