Dana BALAS-TIMAR
Aurel Vlaicu University of Arad

IS IT PSYCHOLOGY ABOUT LINEAR OR DYNAMIC SYSTEMS?

Empirical studies

Keywords

Organizational psychology
Dynamic systems
Chaos theory
Nonlinearity

Abstract

Advances in Physics and Mathematics have proven that our complex world does not obey anymore the standard linear modelling systems rules. This paradigm seems to take over much of the scientific research in all sciences. Psychologists, no matter what their orientation is, are striving to create global models that can explain and predict human behaviour and emotions. In this quest, there have been elaborated many meta-analyses that gather relevant findings in order to create a conceptual framework of understanding human behaviour and affect. This paper presents arguments for sustaining the curvilinear relationships hypothesis that occur between variables (job satisfaction, job performance, age) in an organizational context research. Conclusions set up a new conceptualization of the variable dynamic relationship inferences in Psychology.

1. Dynamic systems in Psychology

As we have stepped into the era of complexity, information does not offer anymore the big picture of researched phenomenon in Psychology. If we are willing to develop comprehensive explanatory and predictive analysis, we must look deeper into our information in order to depict patterns of behaviours for our studied systems. Our prolific tool for searching answers is of course, mathematical modelling and predictive statistics. Much of artificial intelligence approaches have been overcome by neural networks and nanotechnology, resources fully available for all researchers.

Analysing recent research in organizational psychology, one may find out that meta-analyses are striving to create global models for explaining organizational behaviour. Most of conclusions yelled research inconsistencies. From the natural point of view, is obvious that when looking at a complex system of interactions such as organizational behaviour, it is almost impossible that two researches to come up with the same results. What does this mean? That our methodology failed, that out mathematics are wrong, or that we simply "take snapshots„ of the same psychological concept from different views. This is not wrong, this is complexity. Just like in quantum physics, when you measure, you get a result, but when you look again, there is no evidence of what you have just found. I believe that this happens also in Psychology. There is no need for new theories, because they simply reflect different perspective of the same concept, but there is a need to look at psychological concepts as if they are complex, nonlinear systems. By doing this, some of game rules will change, but most of them, don't.

Carver and Scheier (1998) note that psychologists "accustomed to thinking in terms of interactions as determinants of behaviour are already accustomed to thinking in nonlinearities" (p. 253). At their simplest level, nonlinear phenomena in psychology include inverted-U hypotheses or models with interaction effects.

Teachman and Gordon (2009) examined the dynamic relationship between ageing and negative affect (neuroticism, anxiety and depression symptoms), uncovering a curvilinear relationship, with mean symptom levels increasing until mid-30s, declining until mid-70s and then increasing again. Other common nonlinear effects in psychology include threshold and ceiling affects (increase in a predictor has no effect on the outcome until a critical level is reached, and vice versa), indirect and interactive effects (moderated and mediated relationships), or different varieties of the generalised linear model (for example, logistic regression).

Chaos theory and complex systems theory is a branch of mathematics and modern physics that describe the behavior of certain nonlinear dynamical systems, those systems exhibiting instability phenomenon called sensitivity to initial conditions, so that relatively long-term behavior (although complying deterministic laws) is unpredictable, that seemingly chaotic (hence the name of the theory).

Chaos theory was formulated by scientist Edward Lorenz in 1960. Lorentz described this as "a phenomenon that seems to take place at random, actually has a regular element which could be mathematically described." In simple terms, there is a hidden order in the seemingly chaotic development of any complex dynamic system.

Chaos Theory's name comes from the fact that the systems described by it are in an apparently disorder. Chaos theory is a field of study in mathematics, physics, economics and philosophy and deals with studying the behavior of dynamical systems that are highly sensitive to initial conditions. This sensitivity is called the butterfly effect. Small changes in initial conditions, such as rounding up numbers, lead to chaotic results, making impossible the anticipation of long-term effects. This happens even though these systems are deterministic, meaning that their future behavior is fully determined by the initial conditions, without the intervention of other random items. In other words, the deterministic nature of these systems does not make them predictable; this behavior is known as "deterministic chaos".

Dynamics, Chaos, Unpredictability Dynamics refers to the way that the state of a variable or the effect of a variable on another change; they can be linear or nonlinear. More interestingly, and in the context of nonlinear dynamics, the term is reserved to denote change in an autoregressive way, such that values of a variable depend on the previous state (and values) of that variable and subsequently influence the next state (Vallacher & Nowak, 1994).

Some psychosocial variables can have immediate consequences, whereas others exert their effects in the longer term such as burnout and posttraumatic stress disorder, depending on the system's ability and resources to recover from instabilities in the longer-term. Since psychology's early days human behaviour has been understood as being intrinsically dynamic (Nowak & Vallacher, 1998), as noted earlier. For example, the life-span perspective takes a developmental approach by considering the individual with respect to their prior history and likely future development. This is an important dimension, as it not only examines the role of different biopsychosocial factors for health and illness, but also puts these on a temporal dimension of transition, growth and development.

The trajectory of behaviour or behaviours of a dynamic system can be described in terms of its attractors. An attractor is a state towards which behaviour gravitates (Carver & Scheier, 1998). A fixed point attractor is one towards which all behaviour inevitably gravitates and leads to a stable state of equilibrium (the final state of a pendulum, death; Carver & Scheier, 1998). A limit cycle (or periodic orbit) attractor is one where behaviour oscillates between two (or more) different states (e.g. homeostatic processes, mood swings, changes in attitudes; (Abraham et al., 1990). A more interesting type of attractor is what is known as a strange attractor, which operates under chaotic dynamics, capable of producing deterministic, yet random and unpredictable behaviour. In models of chaotic attractors even arbitrary changes in initial conditions can produce dramatic changes in later states through repeated iterations (Carver & Scheier, 1998).

Sensitive dependence on initial conditions, also called the 'butterfly effect', was termed by the meteorologist Lorenz after the popular metaphor that the flapping of the wings of a butterfly can ultimately result in a storm in a distant part of the plane. Sensitivity to initial conditions arises from the inherent dynamic properties of a system, not from randomness of impinging events, nor from a large number of degrees of freedom (Marr, 1992). Initial conditions are sometimes arbitrary starting points and behaviour can often be influenced by slight perturbations introduced at any point in time (Mandel, 1995). A familiar concept in psychology and organizational science, this phenomenon has been linked to Bandura's concept of "sensitive dependencies", such that "the unforeseeability and branching power of fortuitous influences make the specific courses of lives neither easily predictable nor easily socially engineerable" (1994, as cited in Mandel, 1995).

One example is the work of Fredrickson and Losada (2005) who, using the broaden-and-build theory of positive emotions (Fredrickson, 1998), applied the Lorenz system to represent the dynamical relations between positivity and positive psychological and social functioning (flourishing). They envisaged that the key predictor in flourishing would be the ratio of positive to negative effect. They found that the bifurcation between flourishing and languishing is positivity to negativity ratio of 2.9, with an upper limit of 11.6. Too much positivity will be harmful but some negativity can be beneficial for the system. The study provides a dynamic temporal perspective to the theory and illustrates how principles of chaos and complexity can be used to understand affect and psychological health.

2. Explaining the relationship between job performance and job satisfaction – a chaos theory perspective

Chaos theory is the "science of patterns, not predictability" (Chamberlain, 1995). At the technical level, chaos theory involves the application of non-linear dynamic mathematical systems theory and multidimensional fractal geometry to continuous and irregular data sets (Mandelbrot, 1977). Chaos theory is the study of complex, and nonlinear systems. It is used to study turbulent events and nonlinear equations (Lent, 1996).

As we have seen, chaos theory has three defining characteristics: (1) chaotic systems are deterministic, (2) chaotic systems are sensitive to initial conditions, and (3) chaotic systems appear random and disorderly but they actually have a sense of order and pattern.

Regarding our current research, we will present the two scales job satisfaction (JSS) and job performance utilized.

One of the most widely used definitions of job satisfaction in organizational research is that of Locke (1976), who sees job satisfaction as a pleasurable or positive emotional state resulting from the appraisal of one's job or job experiences (Locke, 1976). As Spector's research (1985) revealed, job satisfaction is assessed at both the global level (whether or not the individual is satisfied with the job overall), or at the facet level (whether or not the individual is satisfied with different aspects of the job). Spector (1985) lists 14 common facets: Appreciation, Communication, Coworkers, Fringe benefits, Job conditions, Nature of the work, Organization, Personal growth, Policies and procedures, Promotion opportunities, Recognition, Security, and Supervision.

Job Satisfaction Survey (JSS) was developed by Paul Spector (JSS, Spector, 1985). Blau (1999) found a reliability coefficient alpha of 0.89, in a longitudinal study. Spector (1985) found positive correlations between all 9 subscales. JSS is freely available for research purposes (Spector, 1985). JSS consists of 36 items describing nine subscales (4 items on each subscale). General job satisfaction score shall be calculated by summing all 36 responses. Thus, the score for each of the nine sub-scales from varies from 4 to 24, and the total score, the sum of the 36 item, ranges from 36 to 216. Items are declarative and are evaluated on a 1 to 6 scale, where 1 means total disapproval and 6 strongly agree with the statement. Some items are positively polarized, others negatively. Items positively polarized graded from 1-6, 1 being strongly disagree and negative items are quoted inversely polarized (one becomes 6, and so on). The items negative polarized are: 2, 4, 6, 8, 10, 12, 14, 16, 18, 19, 21, 23, 24, 26, 29, 31, 32, 34, 36.

Testing for reliability, we have found a Cronbach Alpha coefficient of 0,78, which indicates a good internal consistency of the scale (N=51)

Job performance regards the appreciated performance on a 1 to 5 scale (where 1 stands for - does not meet standards and 5 for - exceeds standards) for the following aspects: 1) job specific knowledge, 2) quality/quantity of work, 3) communications, 4) interpersonal skills, 5) organization, planning and process thinking, 6) judgment and decision making, 7) customer satisfaction, 8) teamwork, 9) adaptability to change, 10) management of human resources (not required for non-supervisory associates) and 11) performance against objectives (optional – attach performance objectives).

For example, *Specific knowledge work context related* was defined as the ability to understand, use and demonstrate technical concepts effectively, meet operating procedures and legal requirements in all aspects; keeping abreast of current developments and trends in area of expertise. Assessors (direct hierarchical supervisor) have ranked this performance criterion by using behavioral anchored scales:

1. Regularly make mistakes because of wrong knowledge on certain standards in complex aspects of the job; shows few signs of improvement, despite previous advice.

2. Holds technical information and/or operating on some standard issues (may be defective occasionally, leading to poor performance) may not be versed in all aspects of the complex processes. Would not normally expect other people to go to this person for technical or operational information because these knowledge gaps. This person should go to others for information rather than perform inadequately due to gaps.

3. General knowledge about all aspects of owning and operating the technical standard of their own job. Would be expected occasionally to double check procedures with others on the most complex tasks.

4. Holds general knowledge of technical and operating procedures for all aspects of their own job and those who are in close contact with it. If you need a person to know both the standard and alternative procedures for carrying out any aspect of this job, you can think of that person as a source.

5. Display specific knowledge and innovative capacity of technical concepts and operating procedures for even the most complex tasks. Most people in the department consider this person an expert on a variety of specific jobs department.

Archival data from 51 current employees who completed tests as part of the employment selection process are included in this study. Data was gathered for job applicants being hired between 18.05.2010 and 16.09.2013. These archival data were collected in March 2014. The archival data include demographic information and organizational data. Of the participants, 56.9% are male. Regarding the hiring year 5.9% became employees in 2010, 19.6% became employees in 2011, 33% became employees in 2012 and 41.2 % became employees in 2013. Employees are aged between 25 and 39. The range of incomes varies from 1.800 Ron (Young graduate) to 37.957 Ron (Production Manager).

Testing for normal distribution of data, for job satisfaction and job performance variables the Kolmogorov-Smirnov coefficient is significant at a p value $p > 0,05$, which indicates normal distribution.

Testing for multicollinearity, we have found tolerance of over 0,20 and VIF under 4, results that indicate that in this model, multicollinearity does not represent a problem.

The main purpose of this study is to highlight the relationship between job performance and job satisfaction inside an industrial multinational company from Arad (51 technical and administrative staff). The present study takes the position that job performance – job satisfaction relationship is a dynamic one, and none of the Judge's models can explain it, unless it is regarded from non-linear perspective.

These considerations lead to **Hypothesis: *Between job performance and job satisfaction there is a dynamic relationship.***

Running the Pearson correlation analysis (N=51), results indicate a negative correlation between job satisfaction (M=158,84; SD=6,373) and job performance (M=3,02; SD=0,786), $r = - 0,331$, at a $p < 0,05$. Although this negative correlation coefficient is consistent with other researcher's results (Clark & Oswald, 1996; Sloane & Williams 2000; Green & Tsitsianis 2005), we cannot integrate these finding in any of Judge's models, more than that, we cannot distinguish causality between them.

Given the dynamic system present in any organizational complex context, this negative correlation means that with increased performance, decreases job satisfaction of employees and vice versa. In our organizational context, where all processes are based on employee's skills and reflect themselves in the degree of demonstrating these skills in the current job, surely there is a tremendous pressure on employees. An excessive workload is harmful over job satisfaction and also health as outlined by Clark (1997) and Golden & Wiens-Tuers (2006).

In the purpose of a deeper understanding of this negative correlation, we will further assume that between the two variables there is not a linear relationship, but a dynamic, curvilinear bond between job satisfaction and job performance, meaning that poor job performance and equally excellent job performance are associated with

decreased job satisfaction, while average performance at work is associated with a higher degree of job satisfaction.
We are presenting in Figure 1 a scatter plot having as independent variable job performance (performanta) and dependent variable job satisfaction (JSS); the curvilinear relationship between the two variables is shown.
Coefficients associated with this relationship are listed below, noting the materiality of ANOVA analysis coefficients and the estimator parameters that are at significant at a $p < 0,04$ (Tabel 1,Tabel 2, Tabel 3).
Thus, hypothesis is confirmed by the results indicating a dynamic curvilinear relationship in the shape of an inverted U, with the effect that both low and high levels of performance are associated with a lower job satisfaction in work and medium performance is associated with higher levels of job satisfaction, as conceptualized from the perspective of Spector (1985).
Cumulative results obtained in this study upon job satisfaction are somewhat contradictory in terms of meta-analyzes presented. We have initially identified a high level of satisfaction per sample, reporting the mean average (m = 158.84, SD = 6,373, minimum 144 maximum of 175) to the JSS standard formulated by Spector; scores included in the range 144-216 belonging to employee characterized by job satisfaction. Then we have found a significant negative correlation between job satisfaction and job performance, and finally we have demonstrated a curvilinear relationship between the two variables.
Although taken separately, the two variables are characterized by a linear trend over time while analyzing them together we see that the system no longer behaves linearly.
Our suggestion in this case would be reviewing the significance of the relationship between job satisfaction and professional performance in future studies analyzing this relationship from a dynamic perspective, not just static.

3. Conclusions and implications

Systems considered to be chaotic aren't really chaotic at all – they are just not as predictable as the cause-effect associated with linear dynamics. In nonlinear systems output is not proportional to input – a little bit of input can produce an enormous change in output – or not. In linear systems change can be predicted by what has happened in the past. In nonlinear systems, change is discontinuous, with sudden unpredictable jumps and sudden transitions resulting from dramatic reorganization (McClure, 1998).
The focus of chaos theory is on the process in which simple systems give rise to very complicated unpredictable behavior, on the other hand complexity theory focuses on how systems consisting of many elements can lead to well-organized and predictable behavior. Self-organization implies that new levels of form, organization and complexity often arise out of the interchanges between organisms and their contexts.
When a complex, nonlinear system becomes stressed or "perturbed", the system becomes unstable; the further the system gets from equilibrium the more unstable it becomes. Human beings as well as organizations experience such a phenomenon as anxiety, fear and stress. The system may make changes to reestablish equilibrium, but these changes will be first-order changes – linear, gradual, segmental, predictable, moderate and incremental.
The inverted U theory is rooted in the drive theory stipulated by Hull (1951). This drive theory states that drive represent a directed, motivated or energized behavior that an individual has towards achieving a certain goal. The main component is performer's level of competencies. Drive theory is focused on the relationship between arousal and performance, seeing it as linear, in other words performance increases in proportion to arousal. Thus, high arousal level results in high performance level, due to the fact that competency is well-learned; if the targeted competency is not well-learned, performance will decrease as arousal increases.
This theory helps explain why beginner employees find it difficult to perform well under pressure. Often entry-level employee's work associated competencies level decreases if they are competing with senior employees using new competencies. This theory also explains how experienced employees perform much better under stress using acquired work competencies. Thus, the impact of arousal on performance is much more complex. An approach in investigating arousal is represented by the inverted U theory developed by Yerkes and Dodson (1908). The inverted U theory states that an increase in arousal causes high performance up to an optimal point, also called moderate arousal level; after this point, high levels of arousal would trigger poor performance. This inverted U theory theoretically explains the dynamic relationship between performance and satisfaction, meaning that, at a certain point, job satisfaction reaches a moderate level, after that starting decreasing.
During clustering analysis, the problematic of outliners has been in the centre of attention for many years. It has been suggested that data should be normalized throughout specific procedures, so there is no place for outliners. These outliners represent actual data that do not fit a normal distribution curve among data for a given research sample. In my opinion outliners represent special data that must be carefully handled in order to depict a pattern of appearance.

In this quest, mediator variables have a strong position, meaning that in a linear system, there are mediator variables that tend to strengthen the effect of independent variable on dependent variables. Mediators will attract, like a gravity force the linear curve of the data distribution. Of course, if the research does not aim the problematic of mediators, one cannot find a logical explanation for non-patterned, shattered data. These phenomenons are occurring in linear systems and they have received a special attention from researchers in I-O Psychology during the last decades.

What if our linear system is a complex dynamic system? When we shift views, we will find our answers in chaos theory, attractors in dynamic systems represent mediators in linear systems; they behave under the same principles.

References:

[1] Abraham, F. D., Abraham, R. H., and Shaw, C. D. (1990). *A visual introduction to dynamical systems theory for psychology*. Santa Cruz: Aerial.

[2] Blau, G. (1999). Testing the longitudinal impact of work variables and performance appraisal satisfaction on subsequent overall job satisfaction. *Human Relations*, *52*, 1099-1113.

[3] Carver, C. S., & Scheier, M. F. (1998). *On the self-regulation of behavior*. New York: Cambridge University Press.

[4] Chamberlain, L. (1995). Strange attractors – patterns in family interactions. In R. Robertson & A. Combs (Eds.) Chaos theory in psychology and the life sciences. Mahwak, New Jersey: Lawrence Erlbaum.

[5] Clark, A. (1997). Job satisfaction and gender: why are women so happy at work?, *Labour Economics*, 4, pp.341-72

[6] Clark, A., & Oswald, A.J. (1996). Satisfaction and Comparison Income, *Journal of Public Economics*, vol.61, pp.359-381

[7] Fredrickson, B. L. (1998). What good are positive emotions? *Review of General Psychology*, *2*, 300-319.

[8] Fredrickson, B. L., & Losada, M. (2005). Positive Affect and Complex Dynamics of Human Flourishing, *American Psychologist*, *60* (7), 678-686.

[9] Golden, L., & Wiens-Tuers, B. (2006). To your happiness? Extra hours of labor supply and worker well-being, *Journal of Socio-Economics* 35 (2006) 382–397

[10] Green, F., & Tsitsianis, N. (2005). An Investigation of National Trends in Job Satisfaction in Britain and Germany, *British Journal of Industrial Relations*, vol.43, n.3, pp.401-430.

[11] Hull, C.L. (1951). *Essentials of behavior*. New Haven, CT: Yale University Press.

[12] Lent, R.W. (1996). Career counseling, service, and policy: Revitalizing our paradigms and roles. The Career Development Quarterly, 47, 58-64.

[13] Locke, E.A. (1976). The nature and causes of job satisfaction. In M.D. Dunnette (Ed.), Handbook of industrial and organizational psychology (pp.1297-1349). Chicago: Rand McNally.

[14] Mandel, D. R. (1995). Chaos theory, sensitive dependence, and the logistic equation. *American Psychologist, 50* (2), 106-107.

[15] Mandelbrot, B.B. (1977). Fractals: Form, chance and dimension. Freeman, San Francisco.

[16] Marr, M. J. (1992). Behavior dynamics: One perspective. *Journal of the Experimental Analysis of Behaviour, 57* (3), 249-266.

[17] McClure, J. (1998). Discounting causes of behavior: Are two reasons better than one? Journal of Personality and Social Psychology, 74, 7-20.

[18] Nowak, A., *Vallacher, R. R.*, & Burnstein, E. (1998). Computational social psychology: A neural network approach to interpersonal dynamics. In W. Liebrand, A. Nowak, & R. Hegselman (Eds.), Computer modeling and the study of dynamic social processes (pp. 97-125). New York: Sage.

[19] Sloane, P.J., & Williams, H. (2000). Job satisfaction, comparison earnings, and gender, *Labour*, 14(3), pp.473-502

[20] Spector, P. E. (1985). Measurement of human service staff satisfaction: Development of the Job Satisfaction Survey. American Journal of Community Psychology, 13, 693-713.

[21] Teachman, B. A., & Gordon, T. L. (2009). Age differences in anxious responding: Older and calmer, unless the trigger is physical. Psychology and Aging, 24, 703-714.

[22] *Vallacher, R. R.* & Nowak, A. (1994). The chaos in social psychology. In R. R. *Vallacher* & A. Nowak (Eds.). Dynamical systems in social psychology (pp. 1-16). San Diego: Academic Press.

[23] Yerkes, R.M., & Dodson, J.D. (1908). The relationship of strength of stimulus to rapidity of habit formation. *Journal of Comparative Neurology and Psychology*, 18, 459-482.

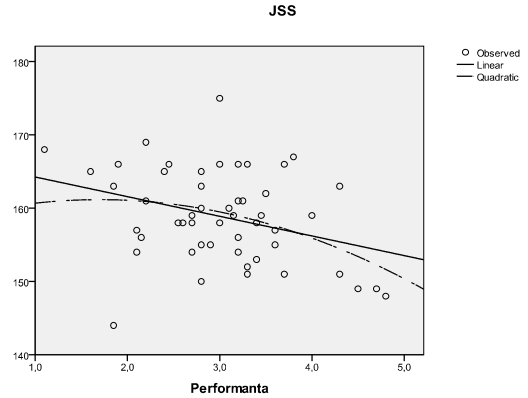

Figure 1 – *The curvilinear relationship between job satisfaction (JSS) and job performance (performanta)*

Tabel 1 - Model Summary

R	R Square	Adjusted R Square	Std. Error of the Estimate
,357	,128	,091	6,075

The independent variable is Job performance.

Tabel 2 - ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Regression	259,415	2	129,708	3,515	**,038**
Residual	1771,330	48	36,903		
Total	2030,745	50			

The independent variable is Job performance.

Tabel 3 - Model Summary and Parameter Estimates

Dependent Variable: JSS

	Model Summary					Parameter Estimates		
Equation	R Square	F	df1	df2	Sig.	Constant	b1	b2
Linear	,110	6,027	1	49	**,018**	166,941	-2,682	
Quadratic	,128	3,515	2	48	**,038**	158,302	3,372	-,991

The independent variable is Job performance.