MAPPING PSYCHOLOGICAL SPACES : PSYCHOTHERAPEUTIC APPLICATIONS OF SYSTEM DYNAMICS IN FUZZY COGNITIVE MAPS OF PERSONAL CONSTRUCTS

LA CARTOGRAFÍA DE LOS ESPACIOS PSICOLÓGICOS: APLICACIONES PSICOTERAPÉUTICAS DE LAS DINÁMICAS SISTÉMICAS DE MAPAS COGNITIVOS BORROSOS DE CONSTRUCTOS PERSONALES

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Abstract

This paper presents an innovative procedure for deriving both Fuzzy Cognitive Maps and Behavior Over Time Graphs from Personal Construct Psychology's Repertory Grids, via the intermediate step of eliciting an adaptation of Bipolar Implications Grids. This makes it possible to have a functional as well as structural model of the Personal Construct System and to test and simulate its anticipated dynamics in hypothetical scenarios, as well as to understand more fully its systemic properties. The paper focuses on the procedure itself, and it is illustrated by means of a case study so as to highlight its significant implications for psychotherapy research and practice.

Keywords: *Repertory grids, fuzzy cognitive maps, bipolar implications grids, system dynamics.*

Resumen

Este artículo presenta un procedimiento innovador para derivar tanto Mapas Cognitivos Borrosos como Gráficos de Comportamiento a lo largo del Tiempo a partir de la Técnica de Rejilla de la Psicología de los Constructos Personales, a través del paso intermedio de obtener una adaptación de Rejillas de Implicaciones Bipolares. Esto permite tener un modelo funcional a la vez que estructural del Sistema de Constructos Personales y probar y simular su dinámica anticipada en escenarios hipotéticos, así como comprender más plenamente sus propiedades sistémicas. El artículo se centra en el procedimiento en sí, que se ilustra mediante un estudio de caso para resaltar sus importantes implicaciones para la investigación y la práctica de la psicoterapia.

Palabras clave: *Técnica de rejilla, mapas cognitivos borrosos, rejillas de implicaciones bipolares, dinámica de sistemas.*

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A representation of personal construct systems (PCSs) that could model not only their structure, but their dynamics, would be immensely useful for psychotherapy practice and research--as well as for many other realms in which *how do people make sense of their world* is a relevant question. The use of cognitive maps to depict the structure of a system (and particularly a conceptual, i.e., not physical, system) has a long tradition in psychology and education. Axelrod (1976) is usually credited as "the first to use digraphs to show causal relationships among variables as defined and described by people, rather than by the researcher" (Özesmi & Özesmi, 2004, p. 44). In fact, concept maps had already been developed in 1972 by Joseph D. Novak and his team at Cornell as means to follow and understand changes in children's knowledge of science (see Novak & Musonda, 1991). The distinctive contribution of Fuzzy Cognitive Maps (FCMs; see Kosko, 1986), as a particular case of cognitive maps, makes them especially useful for achieving the aforementioned aim of modeling the dynamics of PCSs.

FCMs resemble standard concept maps because they are composed by a set of nodes and edges connecting them. The difference, however, is that in a FCM nodes are understood as *fuzzy sets*, and weighted edges (also *non-binary*) as the *causal* relationship among the nodes they connect. A fuzzy (vs. a *dichotomous* or *crisp*) set is one in which the membership of its elements is not limited to 1 ($a \in A$) or 0 ($b \notin A$) but can assume a range in the interval [0,1]. Thus, for instance, if ${}_{A}(x)$ is the membership function of element x to set A, then membership to the fuzzy set A of "happy people" does not limit to the ones being 100% happy 100% of the time ($x \in A \rightarrow {}_{A}(x) = 1$) with *all* the other ones not belonging to the set ($\neg x \notin A \rightarrow {}_{A}(\neg x) = 0$), but can assume a membership degree covering the interval [0,1]; for example, x = *slightly* happy $\rightarrow {}_{A}(x) > 0{,}2 < 0{,}4$; x = *mostly* happy $\rightarrow {}_{A}(x) > 0{,}5 < 0{,}6$; x = *quite* happy $\rightarrow {}_{A}(x) > 0{,}8 < 0{,}9$; or x = *absolutely* happy $\rightarrow {}_{A}(x) > 0{,}9$. The edges weight indicate the extent to which the one who draws the map believes that the connected nodes are causally related, and the direction of causality is indicated by an arrowhead. The usual practice is to assign a +1 weight when one node (*driver*) causally *increases* the connected one (*receiver*), and a -1 when it *decreases* it. Of course, being an FCM, it would be perfectly acceptable to assign any weight in the interval [+1, -1] to a causal edge, but precisely because of the complexity and linguistic nature of the systems that are usually mapped it is infrequent to be able to quantify causality with such minute precision.

Figure 1 depicts a simple FCM made up of only three nodes and three edges. It can be easily understood in linguistic terms: according to the person who drew the map, happiness increases (+) well-being which increases (+) health, and health increases (+) happiness in its turn.

Figure 1. *FCM made up of Three Nodes and Three Edges*

FCMs are a promising tool in terms of modeling the dynamics of PCSs, because:

(a) As I highlighted, they constitute *causal* pictures of the world as constructed by the one who draws the map, and not necessarily as it "objectively" is, a notion that is totally coherent with Personal Construct Psychology (PCP) focus on what constructs do people use so as to make sense of their experience. However, they can be used as prototypes/models/replicas of the discursive domain they represent and tested against "reality" to check to what extent do they anticipate what is actually the case, which is exactly the role that Kelly (1955/1991) attributed to PCSs. In the example in figure 1 it can be easily seen how both the concepts and the relationships among them are the mapper's *personal construction* of this discursive domain (however convincing this construction may be).

(b) Are specifically designed to use with linguistic variables that are intrinsically fuzzy, i.e., not necessarily with mathematically crisp sets. In this respect they are also coherent with PCP because constructs are essentially a linguistic way to make sense of experience and they do not assume an *all or none* relationship with the elements they make sense of, but rather a degree of membership of the elements to the set that the construct defines, and thus a given element can vary from totally belonging to one pole to totally belonging to the opposite one. Again, in the example in figure 1, it becomes obvious that "Health", "Well-being", and "Happiness" are the emerging poles of constructs that the mapper's use to "anticipate events by construing their replications" in Kelly's (1955/1991) terms. Thus, this particular FCM organization makes one anticipate that "if one is happy then one will also have a high degree of well-being and be healthy". It also assumes that one can have *more or less* of these three qualities, not necessarily all or nothing.

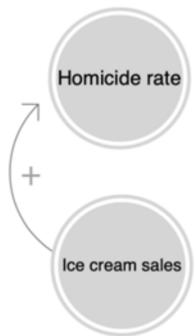
(c) Can be "set in motion" by activating one or more nodes and using them thus as a form of simulation and "what-if" anticipation. Precisely because FCMs are causal pictures, activating one node makes "causal flow" (Kosko, 1993) circulate through the whole map, and it becomes visible what other nodes are causally activated (or deactivated) as a consequence, and what happens to the system as a whole over time. This possibility (about which I will say more in the rest of the paper) enriches enormously the typical analysis of PCSs that is limited to a fixed image of the state of the system in a given point in time. It also opens the possibility of incorporating the developments of systems thinking and system dynamics both to PCSs research and practice. The simple FCM in figure 1 again illustrates this pont: it is almost self-evident what will happen to each node (and to the system as a whole) if one increases one of them. Because they are all connected by positive causality edges, creating a reinforcing feedback loop, activating one node will activate all the other ones until the system reaches a stable state (which some FCMs do not reach, entering cyclical loops or chaotic randomness).

In the remaining of this paper, I will discuss how can Repertory Grid (RG) data be turned into FCMs, what usefulness do this have in terms of analyzing PCSs causal loops diagrams and Behavior Over Time Graphs (BOTGs), and what are some of the promising implications of the above for psychotherapy research and practice. I will use a case example to make it clearer. Before proceeding, however, I would like to make explicit that FCMs can be derived from *any other form* of eliciting constructs, not only from RGs. The content of self-characterizations, self-narratives, dialogue, journals, letters, interviews, therapy sessions… and virtually any form of personal expression can be graphically depicted as a map of construct pole nodes and (to the extent that causality is made explicit) the edges connecting them.

From Repertory Grids to Fuzzy Cognitive Maps via Bipolar Causal Implication Grids

As already discussed, FCMs are *causal* pictures of the world. It is crucial that this be so, because if what they depict are only *correlations* and not *causality* then their dynamics will have a confusing meaning. Imagine any of the classic examples of how correlation does not imply causation, such as the correlation between *ice cream sales* and *homicide rates*. If this correlation is mistakenly interpreted as causation the consequent FCM looks like the one in figure 2.

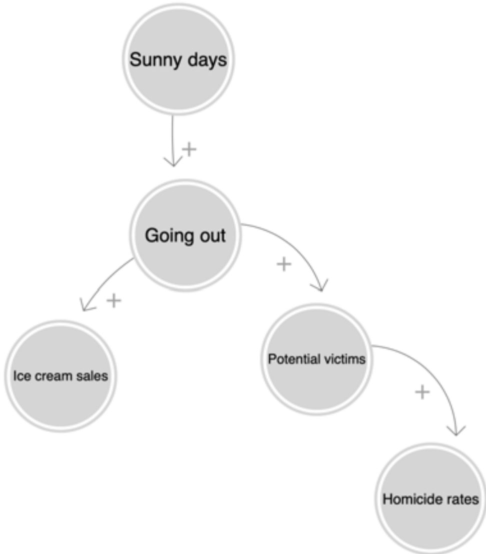
Figure 2. *FCM Depicting False Causation*



If the node “ice cream sales” is activated in the FM in figure 2 it automatically increases the homicide rates because of the mistakenly attributed positive causation between the two. This erroneous dynamic might lead to defend a ban on ice cream for example if one takes it seriously.

Obviously, the causal connection between these two nodes is more like the one in the FCM in figure 3.

Figure 3. *FCM Depicting Plausible Causality*



Since the relations between RG rows (constructs) or columns (elements) define correlations, but not causation, to draw FCMs from RG data an intermediate step is needed: Implications Grids (also called Impgrids: Hinkle, 1965).

Hinkle introduced the Impgrid as a method to determine the position of one construct within the PCS in terms of its hierarchy, assuming that each one carries different *implications* (i.e., *predictions*, *anticipations*, *expectations*) over the others. Impgrids entail presenting the person with the *two poles* of each construct he or she has elicited in the RG and asking whether a change on construct 1 (from one pole to the opposite one) would be likely to cause the same type of change on each of the other constructs, pairing each construct with all others.

Fransella (1972) developed the Bipolar Implications Grid, much more suited to our goal of deriving FCMs from RGs data. In this variety of Hinkle’s original proposal, the person is presented with each pole of his or her constructs *separately* and is then asked what poles of all the other constructs would be expectable from someone who is described by the presented pole.

Bipolar Implication Grids can thus be used to assess *causal* implications between constructs by emphasizing in the eliciting question the causal link between each pair of poles. Fransella’s original question was “*If someone is x, what is he or* *she likely to be?*", and so as to make sure that we were assessing *causal connections* and *not just correlations*, we adapted the question to: *"Being x, what makes one be as well (either more or less)?"* The second clause was added because we were interested in assessing both positive/incremental and negative/decremental causation.

As an example of this procedure table 1 presents a client's (Patrick) original RG simplified to five constructs and five elements so as not to make the discussion in this paper too mathematically complex.

Table 1. *Patrick's Original RG (Simplified)*

1	Father	Mother	Tom (brother)	Self Now	Ideal Self	5
Committed	1	5	1	4	1	Egocentric
Confident	5	1	2	4	1	Suspicious
Hedonistic	4	1	1	4	1	Embittered
Flexible	5	1	5	4	1	Stubborn
Honest	1	5	4	2	1	Liar

Patrick, a 25 year old Sociology student, came to therapy because, after breaking up with his partner and with a close friend because of what he defined as "a treason", he was feeling that he was "not the kind of person I used to be or would like to be". This is obvious in this reduced version of his original RG, in which his "myself now" and "ideal self" elements are almost at every construct opposite pole. Patrick was construing himself when he came to therapy as rather egocentric (vs. committed), suspicious (vs. confident), embittered (vs. hedonistic), and stubborn (vs. flexible). The only construct in which he was already at his preferred pole was honest (vs. liar). Patrick was experiencing mood swings, depression, anger, anxiety and feelings of meaninglessness since the moment he ceased to be the person he would like to be.

After completing the RG, Patrick was presented with each pole of his five constructs (for instance, "Committed") and asked: *"Being committed, what makes one be as well (either more or less)?"* In this particular case, he said that *being committed makes one be more confident, more honest, less egocentric, less suspicious, less embittered, and less of a liar*.

The results of each construct pole causal implications for each other one, as elicited by Patrick, are presented in table 2 (the reason for some cells to be shadowed is explained later).

Table 2. *Matrix of Causal Implications between Patrick's Construct Poles*

	Committed	Confident	Hedonistic	Stubborn	Honest	Egocentric	Suspicious	Embittered	Flexible	Liar
Committed	0	1	0	0	1	-1	-1	-1	0	0
Confident	1	0	0	0	1	-1	-1	-1	0	-1
Hedonistic	0	0	0	0	0	0	-1	-1	0	0
Stubborn	0	0	0	0	0	1	1	1	-1	0
Honest	1	1	0	0	0	0	-1	0	0	-1
Egocentric	-1	-1	0	0	0	0	1	1	-1	0
Suspicious	-1	-1	0	0	0	1	0	1	-1	0
Embittered	-1	-1	-1	0	0	1	1	0	-1	0
Flexible	0	0	0	-1	0	-1	-1	0	0	0
Liar	-1	-1	0	0	-1	0	1	0	-1	0
OUTDEGREE[1]	6	6	1	1	3	6	9	6	5	2
INDEGREE[2]	5	6	2	4	4	5	5	6	6	5
Difference[3]	1	0	-1	-3	-1	1	4	0	-1	-3

Note:

[1] Number of causal connexions that the construct pole sends (drivers)

[2] Number of causal connexions that the construct pole receives (receivers)

[3] Outdegree - Indegree

If table 2 is read by columns (taking "Confident" in this case as an example) the information it presents is: *According to Patrick being confident makes one be more committed, more honest, less egocentric, less suspicious, less embittered, and less of a liar*.

Before proceeding to discuss how this matrix of causal implications is transformed into a FCM and a matrix of system states, there are some relevant points to highlight.

1. The difference between outdegree and indegree is a likely indication of the construct pole's *driving capacity*, i.e., to what extent is it central *in* and *to* the system. Thus, "Suspicious" is likely to be very central in Patrick's PCS because being suspicious makes one be *nine* other things, while only five of them makes one suspicious. This means that if Patrick changes his construction of someone (including himself) to more or less suspicious than he used to think, nine other construct poles will be changed as a consequence. Being "Hedonistic", instead, only makes one be less embittered (outdegree = 1) according to Patrick's PCS, and is a consequence of being less suspicious and less embittered (indegree = 2). Along the

lines of Hinkle's (1965) and Fransella's (1972) hypotheses (as well as of the logic of system dynamics in general), "Hedonistic" is thus logically expectable to be less central and thus more peripheral to Patrick's PCS than "Suspicious" since a change in the second generates nine times more system changes than a change in the first.

2. The central diagonal of the matrix is 0 because the procedure does not include asking whether *being committed* (for example) *makes one more or less committed*. The question seems logically absurd and a literal tautology in itself.

3. The lateral diagonals of the matrix (in grey in table 2) are the ones formed by the cells that connect one construct pole to its opposite one. They were fixed as -1 because a value of 0 or 1 would mean that being defined by one pole *does not* make one be less of the other (e.g., that *being honest does not make one less of a liar*) or that being defined by one pole makes one be also *more* of the other (e.g., that *being flexible makes one more stubborn*). If any of these were the case, the polarity would not be a construct, and in fact it would not even be a polarity, which is incompatible with the way the original RG has been elicited. So, the interview procedure in this part also excludes asking about one pole against the other one of the same construct, because a positive or null causal relationship between opposite poles is not theoretically, methodologically, or even logically consistent.

4. Knowing which are the positive/preferred poles of each construct (because of the scoring of the "ideal self" element in the original RG) makes it possible to mark them as it has been done in table 3, where poles in black are the negative (non-preferred) ones and poles in white are the positive (preferred) ones. As can be seen in the table, this makes it also possible to identify whether a cell contains a positive/positive link (for example *confident/committed*), a positive/negative one (for example *hedonistic/stubborn*), or a *negative/negative* one (for example *egocentric/suspicious*). The cells containing a positive/negative or negative/positive link have been marked in grey in table 3 –because they are where black and white combine.

Table 3. *Matrix of Causal Implications between Patrick's Construct Poles with Positive ones in White and Negative ones in Black*

	Committed	Confident	Hedonistic	Stubborn	Honest	Egocentric	Suspicious	Embittered	Flexible	Liar
Committed	0	1	0	0	1	-1	-1	-1	0	0
Confident	1	0	0	0	1	-1	-1	-1	0	-1
Hedonistic	0	0	0	0	0	0	-1	-1	0	0
Stubborn	0	0	0	0	0	1	1	1	-1	0
Honest	1	1	0	0	0	0	-1	0	0	-1
Egocentric	-1	-1	0	0	0	0	1	1	-1	0
Suspicious	-1	-1	0	0	0	1	0	1	-1	0
Embittered	-1	-1	-1	0	0	1	1	0	-1	0
Flexible	0	0	0	-1	0	-1	-1	0	0	0
Liar	-1	-1	0	0	-1	0	1	0	-1	0

5. From table 3 there emerge some implications about what should happen if the PCS were 100% internally consistent:

(a) All white table cells should have a scoring of 1 (being like a positive pole makes one to be like another positive one because both poles are causally related, e.g., *being honest makes one committed*) or 0 (being like a positive pole makes no difference for being like another positive one because one pole is not causally related to the other, e.g., *being confident does not make one neither more nor less hedonistic*).

(b) All black cells should have a scoring of 1 (being like a negative pole makes one be more like another negative one because both poles are causally related, e.g., *being egocentric makes one stubborn*) or 0 (being like a negative pole makes no difference for being like another negative one because one pole is not causally related to the other, e.g., *being embittered does not make one neither more nor less of a liar*).

(c) All grey cells should be scored -1 (being like a positive pole makes one be less like another negative one or viceversa because both poles are causally related, e.g., *being honest makes one less of a liar*) or 0 (being like a positive pole makes no difference for being like another negative one or viceversa because one pole is not causally related to the other, e.g., *being hedonistic does not make one neither more nor less egocentric*).

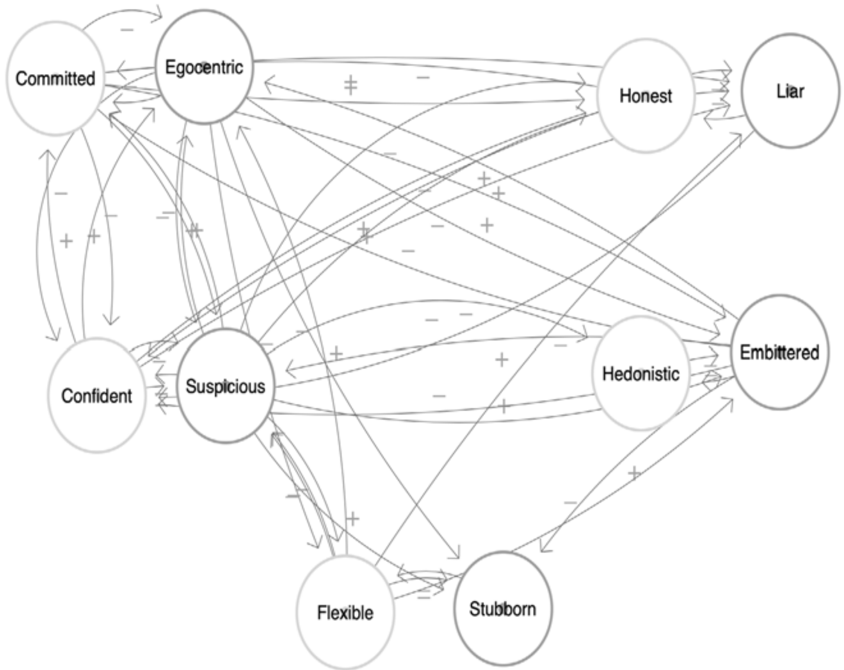
(d) If a white table cell is -1 or a grey cell is 1 then this indicates that in this PCS being like a positive pole of a construct makes one be less like another positive one (there are no instances in Patrick's case).

(e) If a black cell is -1 or a grey cell is 1 this indicates that in this PCS being like a negative pole of a construct makes one be less like another negative one (there are no instances in Patrick's case either).

Having briefly discussed these emerging implications, worth exploring further in the future because of their potential significance for an altered functioning of the PCS, I proceed to discuss how an FCM, as well as a matrix of system states, can be derived from these causal implication data.

Drawing a FCM from the data in the matrix of causal implications is just a question of drawing all construct poles as nodes and then proceed to draw all causal implications between each one of them and all the rest as arrows connecting construct pole nodes (edge relationships). The result in Patrick's case is the one depicted in figure 4.

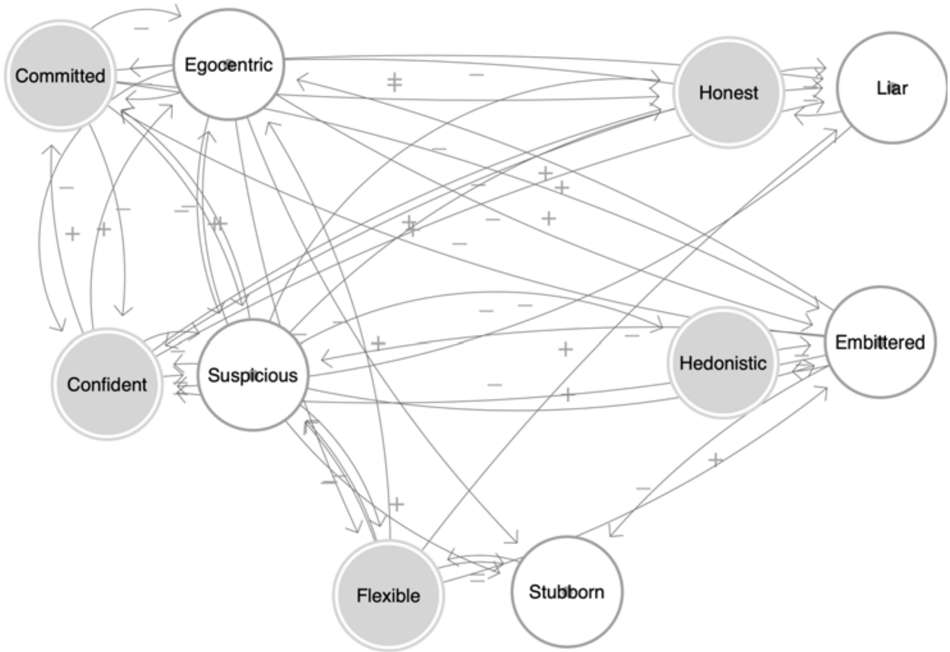
Figure 4. *Patrick's PCS FCM*



As can be seen in figure 4 even a simple PCS with only five constructs (i.e., 10 construct pole nodes) can generate a quite complex FCM with a dense network of edge connections that is not easy to interpret visually *per se*. The reason for such a complexity lies in the well-known systems characteristic that complexity does not emerge from the number of *components* of a system (construct pole nodes in this case) but from the number of *relationships/interactions* (edge causal connections) between them. However, the usefulness of map-like models is made clear when they are put into motion and this makes it visible what happens to the system once causal flow begins to circulate.

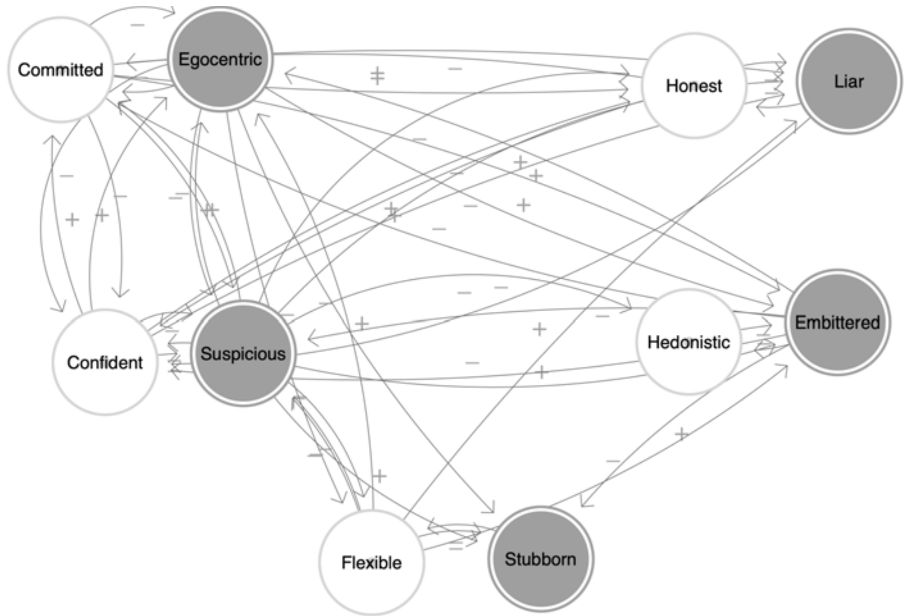
As already discussed, activating one construct pole node sets the whole system into motion and makes it possible to simulate "what-if" scenarios like "*What would happen if Patrick began construing himself as confident instead of quite suspicious as he does now?*" The limitations of a static paper format does not allow me to show the dynamics of what happens to the FCM of Patrick's PCS in "real" time and seeing the causal flow circulating in motion, but it can be described: because of the way his system is structured and causally connected, if any positive construct pole node is activated then every other positive one becomes active also and quite immediately, and every negative one remains or becomes inactive. This leaves the system in a state in which all positive construct pole nodes are active at once and all negative ones are inactive (see figure 5). The same state is reached if any negative construct pole node is decreased.

Figure 5. *Patrick's PCS FCM Final State if any Positive Construct Pole Node is Increased or any Negative One is Decreased*



Conversely, if any negative construct pole node is increased or any positive one is decreased, Patrick's PCS FCM converges rapidly in a state in which all negative poles are active and all positive ones are not (see figure 6).

Figure 6. *Patrick's PCS FCM Final State if any Positive Construct Pole Node is Decreased or any Negative One is Increased*



Another way to depict the system's dynamic over time is by means of what system scholars call "*Behavior Over Time graphs*". BOTGs are, quite literally, a line graph that depict a pattern of change over time, showing how something increases and decreases as time passes. In the case of FCMs, the matrix of causal implications (edge relationships) can be used to compute a matrix of the state of all construct pole nodes in the system at each moment in time starting when any construct pole node is activated. This entails establishing a *threshold function* that computes the state of each construct pole node at each moment in time t_x as a mathematic function of the state of all its drivers at t_{x-1}. FCMs traditionally employ a number of different threshold functions (binary, trivalent, sigmoid…) and in this case we have opted for an additive one that adds the value of all drivers that each construct pole node A (CPN_A) receives so as to compute its activation state at any t_x ($CPN_A(t_x)$) and if it is greater than 1 or smaller than -1 reduces it to the range [-1, 1]:

$CPN_A(t_x) > 1 \rightarrow CPN_A(t_x) = 1$

$CPN_A(t_x) < -1 \rightarrow CPN_A(t_x) = -1$

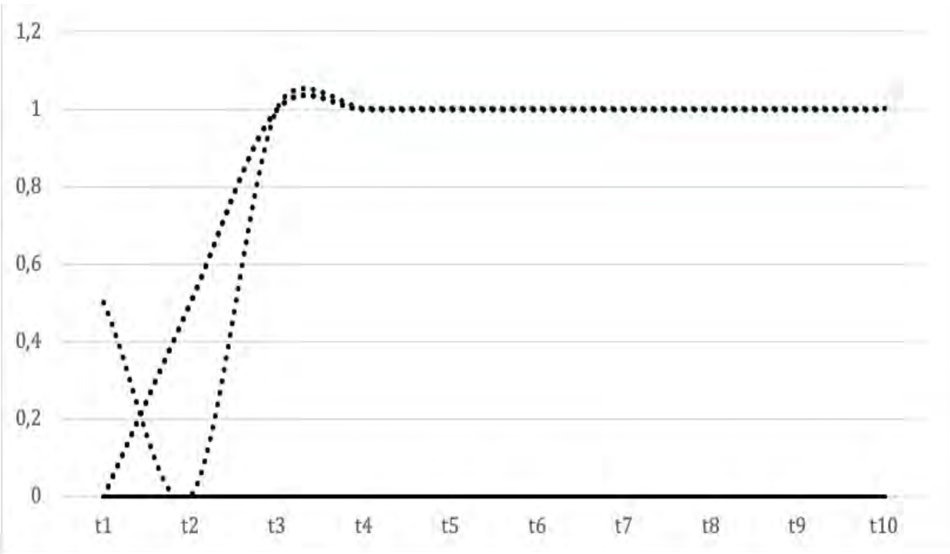
Thus, if for instance the construct pole node "Committed" is set to 0,5 at t_1 then it will activate its six receivers at t_2 with a 0,5 value, and each one of them in combination will activate their own receivers at t_3 (and so on until, again, a state of equilibrium is reached at t_n or the system enters into cyclical loops or chaotic fluctuations).

This successive sequence of system states in time ($t_{1,}$ $t_{2...,}$ t_n) can be represented graphically, and this makes it possible to see the (past or anticipated/simulated) history of the system in a single image, i.e., *diachronically* and not only *synchronically* as is the case with the map representation of FCMs. The BOTG in the case of Patrick's PCS is presented in table 4 in its matrix form and in figure 7 as a graph. Time has been limited to 10 system iterations because this system converges rapidly (at t_4)--if this were not the case it can be extended as necessary so as to look for dynamic patterns.

Table 4. *System States Matrix for Patrick's PCS FCM Activating the Construct Pole Node "Committed" with a 0,5 Value at t_1*

	t_1	t_2	t_3	t_4	t_5	t_6	t_7	t_8	t_9	t_{10}
Committed	0,50	0,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
Confident	0,00	0,50	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
Hedonistic	0,00	0,50	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
Stubborn	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Honest	0,00	0,50	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
Egocentric	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Suspicious	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Embittered	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Flexible	0,00	0,50	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
Liar	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00

Figure 7. *BOTG for Patrick's PCS FCM Activating the Construct Pole Node "Committed" with a 0,5 Value at t_1*



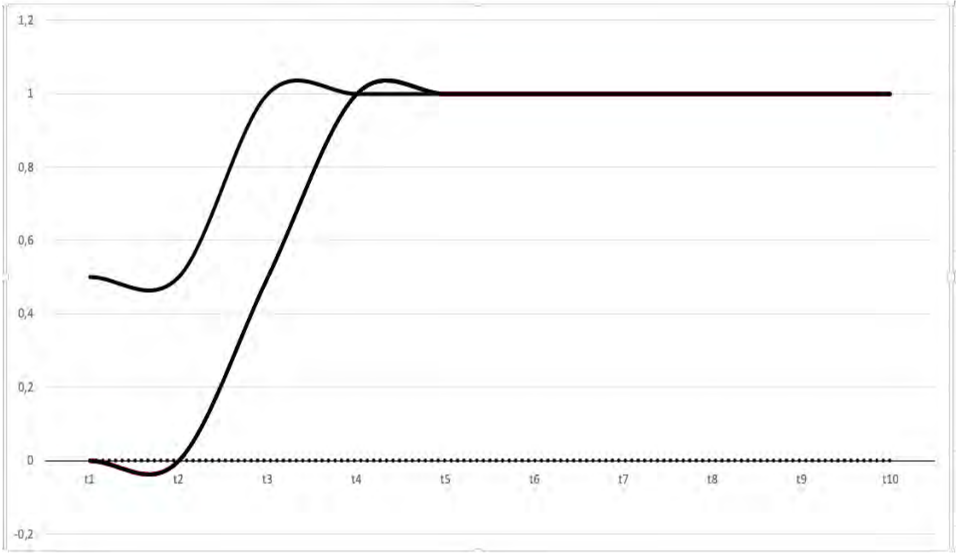
The combined analysis of table 4 (matrix) and figure 7 (BOTG) makes it obvious that what happens to Patrick's PCS FCM if the positive pole "Committed" is increased is exactly what the map model in figure 5 showed: if any positive pole (the dotted lines in figure 7) is activated then every other positive one becomes active as well, and quite rapidly, and every negative one (continuous line in figure 7) becomes inactive.

Again, as in the case of figure 5 vs. figure 6, table 5 and figure 8 show exactly the opposite system behavior from table 4 and figure 7: if any negative pole (the continuous lines in figure 8) is activated then every other negative one becomes active as well and quite immediately, and every positive one (dotted line in figure 8) becomes inactive.

Table 5. *System States Matrix for Patrick's PCS FCM Activating the Construct Pole Node "Stubborn" with a 0,5 Value FCM Activating the Construct Pole Node "Committed" with a 0,5 Value at t_1*

	t_1	t_2	t_3	t_4	t_5	t_6	t_7	t_8	t_9	t_{10}
Committed	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Confident	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Hedonistic	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Stubborn	0,50	0,50	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
Honest	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Egocentric	0,00	0,00	0,50	1,00	1,00	1,00	1,00	1,00	1,00	1,00
Suspicious	0,00	0,00	0,50	1,00	1,00	1,00	1,00	1,00	1,00	1,00
Embittered	0,00	0,00	0,50	1,00	1,00	1,00	1,00	1,00	1,00	1,00
Flexible	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Liar	0,00	0,00	0,50	1,00	1,00	1,00	1,00	1,00	1,00	1,00

Figure 8. *BOTG for Patrick's PCS FCM Activating the Construct Pole Node "Stubborn" with a 0,5 Value at t_1*



The combined use of map-like graphic representations and BOTG ones makes it possible to observe the same PCS dynamic in different ways. In the case of Patrick, for instance, observing his PCS FCM in motion in the map-like version makes it clearly visible that the reinforcing (i.e., positive feedback) loops that tightly link the positive node poles of his PCS together, combined with the also reinforcing loops (but separate from the positive) that link the negative node poles, makes the system enter into a split escalation dynamic almost immediately, even if just one construct pole node is increased or decreased. This escalation leads the system to converge either at a split state in which all positive poles are active and all negative ones are not or viceversa. Systems thinking concepts are quite useful to understand, explain, and plan how to change the PCS when seen from this map-like models.

Seen from the BOTG, the same system dynamics become even more clear. Patrick's PCS converge in a dichotomous but stable state in just a few time lapses and as a consequence of what we already knew from the map-like model: activating any single positive construct pole node or deactivating any negative one lead the system towards the orbit of a fixed-point attractor consisting in the activation of all the positive ones and the deactivation of all the negative ones. The exactly opposite process happens as well. Complex and non-linear system concepts, as well as chaos theory ones, are quite useful to understand, explain and plan how to change the PCS when seen from this BOTGs models.

Therapeutic Usefulness of PCSs FCMs

As I mentioned in the opening of this paper, a representation of PCSs that model not only their structure, but their dynamics, is immensely useful for psychotherapy practice and research.

In the case of Patrick, for instance, it contributed very significantly to the therapeutic process by allowing both therapist and client to build a dynamic model of Patrick's PCS and use it as a tool for (a) reaching a better, deeper, and absolutely personal understanding of Patrick's difficulties as well as resources, (b) devising Patrick's therapeutic goals as constituting an alternative system (i.e., meaningfully *different* one, not necessarily the *opposite* of the problematic one) and planning how to get from one to the other with the help of the therapy process, (c) testing "what-if" scenarios, identifying risks, roadblocks, and likely difficulties and how to approach them, and adapting the pace of change to what Patrick considered viable, and (d) checking whether Patrick had reached his goals once therapy was coming to an end.

In summary, a tool for mapping the psychological space and anticipating/simulating its system dynamics (be them "intrapsychic" as in Patrick's example or interpersonal as in family or couples therapy) can help psychotherapy practice and outcome/process research advance significantly in understanding *how* clients change. The combination of concepts from PCP and FCMs seem to be especially useful for building these tools, and it opens the space for a fruitful integration of system dynamics concepts on the one hand and complex systems, non-linear dynamics and chaos theories ones on the other.

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