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CHARLES E. SCHMIDT COLLEGE OF SCIENCE

Mathematical Model of the Dynamics of Psychotherapy

Michael D. Norman , Larry Liebovitch, Paul Peluso

Center for Complex Systems and Brain Sciences, Charles E. Schmidt College of Science, Florida Atlantic University, Boca Raton, FL

The success of psychotherapy depends on the nature of the therapeutic relationship between a therapist and a client. We use dynamical systems theory to model the dynamics of the emotional interaction between a therapist and client. We determine how the therapeutic endpoint and the dynamics of getting there depend on the parameters of the model. Studies have sought to identify the most essential elements of this relationship. Although, those elements are not fully understood, previous psychotherapy studies have reported that the essential element is the personal relationship between the therapist and client, rather than an abstract theoretical framework used by the therapist. This suggests that a model that describes how two people, a dyad, react to themselves and to each other can represent some features of this relationship. Previously Gottman et al. used a very similar approach (physical-sciences paradigm) for modeling and making predictions about husband-wife relationships. They modeled their interactions using difference equations and then compared the behavior of those equations to the experimental data of affect coded from video of married couples in a 15-minute discussion. The parameters they determined in this way had high predictive value of whether the marriages were stable and also gave new insights into the dynamics of how couples interact. Since that novel approach shed light on the dyadic interaction between couples we thought that it also had the possibility to give us new insights into the relationship between therapist and client.

Mathematical Model of Psychotherapy: A New Approach to Understanding the Therapeutic Relationship

Michael D. NORMAN¹, Larry S. LIEBOVITCH^{1,2}, Paul R. PELUSO¹, John M. GOTTMAN³ & Jessica SU¹

¹Florida Atlantic University, Boca Raton FL, ²Queens College, Flushing NY and ³University of Washington, Seattle WA

Introduction

The success of therapy depends on the nature of the therapeutic relationship between a therapist and client.

Studies have sought to identify the most essential elements of this relationship. However, the essential elements and the dynamics of how this relationship works are not yet fully understood.

Previous studies have used the social science paradigm of determining the functional correlations between dependent and independent variables.

However, novel paradigms may yield new insights into this problem. Gottman et al. used a paradigm from the physical sciences to analyze the relationship between husband and wives. They modeled their dyadic interactions in mathematical equations and then compared the behavior of those equations to the experimental data of affect coded from video tapes of married couples in a 15-minute discussion. The parameters they determined in this way had high predictive value of whether the marriages were stable and also gave new insights into the dynamics of how couples interact.

Since that novel approach shed light on the dyadic interaction between couples we thought that it also had the possibility to give us new insights into the dyadic relationship between therapist and client.

Mathematical Model

Equations

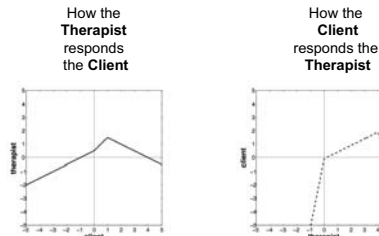
$$\frac{dx}{dt} = m_1x + b_1 + f_1(y,x)$$

$$\frac{dy}{dt} = m_2y + b_2 + f_2(x,y)$$

Variables

x = emotional state of the therapist
y = emotional state of the client

Influence Functions $f_1(y,x)$ and $f_2(x,y)$



Results

- Figures 2,4:** The member of the dyad that is most responsive to the other achieves the most positive state. This suggests that the successful strategy of a low reactivity therapist, developed intuitively over many years, may have a basis in the dynamics of how dyads interact.
- Figures 2,4:** Under most circumstances, when the client approaches a good state, this approach is reached through a spiral trajectory, meaning that the client (and therapist) will necessarily go through up and down emotional swings before reaching their final steady states.
- Figures 1-5:** The therapist can help direct a client starting from either a negative or positive emotional state to a good outcome only if the therapist starts from a positive emotional state. A therapist starting from a negative emotional state is never good for the client.
- Figures 2,3:** Increasing the influence of the other person yields the same dynamical trajectory as responding more weakly to your own previous emotional state.

SUMMARY

What constitutes a good therapeutic relationship?

We use ordinary differential equations to model the dynamics of the emotional interaction between therapist and client.

The solution of these equations shows how the therapeutic endpoint and the dynamics of getting there depends on how the therapist and client influence each other.

Michael D. Norman
mnorman5@fau.edu

Larry S. Liebovitch
larry.liebovitch@qc.cuny.edu

Paul R. Peluso
ppeluso@fau.edu

Figure 1:
Base Case

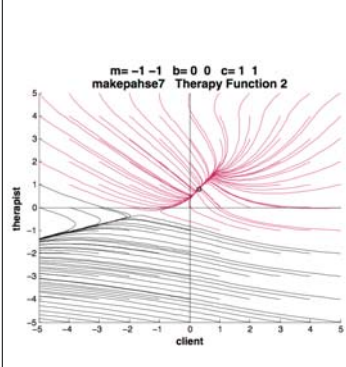


Figure 2:
Client Responds STRONGLY to Therapist

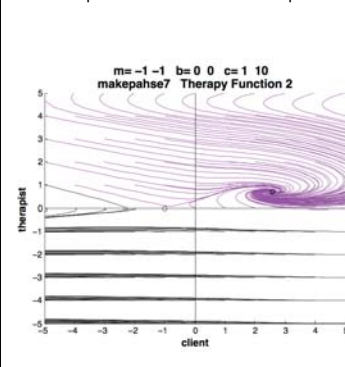


Figure 3:
Client is LESS Dependent on the Past

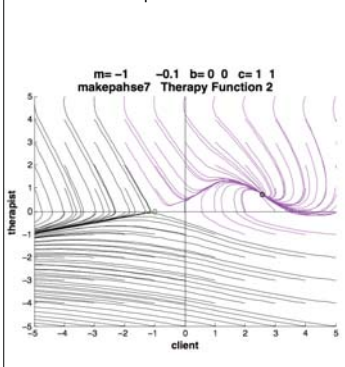


Figure 4:
Therapist Responds STRONGLY to Client

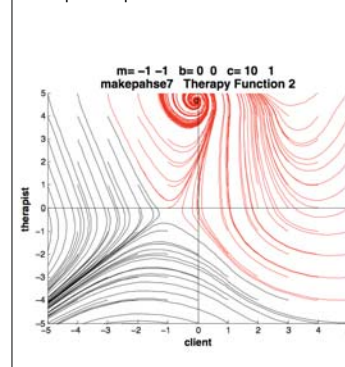


Figure 5:
Therapist and Client BOTH Respond STRONGLY to Each Other

