

## A complex and chaotic view of health behavior change

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Resnicow, K. & Vaughan, R. (2006). A chaotic view of behavior change: a quantum leap for health promotion. *International Journal of Behavioral Nutrition and Physical Activity* 3(1): 25.

Resnicow, K & Page, SE (in press). Embracing Chaos and Complexity: A Quantum Change for Public Health. *Am J Public Health*. 2008;98:xx

## Theory ???

Social Cognitive Theory		Theory of Relativity
Health Belief Model		Big Bang Theory
Theory of Reasoned Action	VS	Evolution
Health Communication Theory		God
Social Ecological Theory		Quantum Theory
Transtheoretical Model**		Gravity
		Perfect Markets
		Random Walk
		Chaos Theory

## Attributes of Useful Theory

Social Cognitive Theory		Theory of Relativity
Health Belief Model		Big Bang Theory
Theory of Reasoned Action	VS	Evolution
Health Communication Theory		God
Social Ecological Theory		Quantum Theory
Transtheoretical Model**		Gravity
		Perfect Markets
		Random Walk
		Chaos Theory

*Parsimonious*  
*Simple explanation for complex phenomena*  
*Unifying*  
*Conceptually distinct*  
*Falsifiable*

## Improbable Headlines

- "Study proves conclusively that social cognitive theory is wrong"
  - Palo Alto Press
- "NIH study proves transtheoretical model is true"
  - Rhode Island Free Press

## Theory vs. Framework

### THEORY

- a plausible or scientifically acceptable general principle or body of principles offered to explain phenomena
- a hypothesis assumed for the sake of argument or investigation or an unproved assumption
- a set of facts, propositions, or principles analyzed in their relation to one another and used, especially in science, to explain phenomena

### FRAMEWORK

- a basic conceptual structure
- a set of ideas, principles, agreements, or rules that provides the basis or the outline for something that is more fully developed at a later stage

## Linear-Newtonian Principles

Linearity— simple relationship between inputs and outputs. Small inputs have small effects, large inputs have large effects.

Reductionism— systems can be understood by breaking them down into their component parts. Main effects.

Determinism—a system can be predicted.

Rationalism---- Behavior can be formulated as the making of a rational choices between alternative means of achieving a known end. More information leads to more rational choices.

## Key Non-Linear Concepts

- 1) Behavior change is often a *quantum* rather than linear event. (small input  $\rightarrow$  large output)
- 2) Behavior change is highly variable and difficult to predict. (non-deterministic)
- 3) Behavior change is *sensitive to initial conditions*.
- 4) Behavior change is a *complex* dynamic system that involves multiple component parts that interact (in a nonlinear fashion) and the results of their interaction are often greater than the sum of their parts. (non-reductionistic)
- 5) Patterns of change can be mathematically modeled, however such patterns usually involve *non-linear terms* and multiple levels of interaction.

"Chaos is a friend of mine"

"I accept chaos but does chaos accept me."

-- Bob Dylan

## Degree of Complexity/Correlated Variability

Too Little  $\leftrightarrow$  Optimal  $\leftrightarrow$  Too Much

Old Age                  Youth                  Infancy

CHF                      Healthy                  V-fib

Sleep  
Gait  
Breathing  
OCD  
Behavior Change?????

## Examples of Quantum Effects

- Tipping Points
- Breaking Points
- Disease Thresholds
- Ice  $\leftarrow$  Water  $\rightarrow$  Steam

## Examples of Chaotic Systems

- Epidemics
- Wars
- Weather
- Mixing Colored Dyes
- Billiards
- Love
- Stock Market
- **HEALTH BEHAVIOR?**

## Complexity and Chaos more relevant to Volitional Behavior

### Reductionist

Low Volition (Gun to the Head)

Environmental Control

Legislative  
Social Norms  
Taxation

### Complex

High Volition (Free Living)

Personal Control

**Chaos/Complexity**

## Deconstructing Motivation

Particle vs. Wave

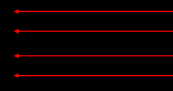
## Human Motivation: Corresponding Intervention Models

Rational  
Knowledge

Emotive  
Attitude

Spiritual/Metaphysical  
Meaning

Planned  
Conscious  
Left Brain  
Linear  
Particle



Epiphany  
Unconscious  
Right Brain  
Chaotic  
Wave

Health Belief Model  
Social Cognitive Theory  
Transtheoretical Model  
Theory of Reasoned Action

Self Determination Theory  
Chaos Theory  
Motivational Interviewing

- Does the cognitive-rational approach work?
- Does it cause harm?
- Is there a better way to conceptualize change?

## Can we outperform monkeys throwing darts?

- Theoretical variables account for no more than 50% variance in behavior change interventions (1)
- About 75% of equity mutual funds underperform the S&P 500 year after year

1. Baranowski T, Lin L, Wetter DW, Resnicow K, Davis M. Theory as mediating variables: Why aren't community interventions working as desired? *Annals of Epidemiology* 1997;7(S7):89-95.

2. Nassim Nicholas Taleb. (2007) *Fooled by Randomness: The Hidden Role of Chance in the Markets and in Life*.

## Consider.....

- Why does someone, after multiple attempts to quit smoking or lose weight finally succeed?
- Do we have any adequate models to predict such events?

## Implications for Health Behavior: Unpredictability of Stickiness

Sample events that can spur an individual to action

- Found out best friend has cancer
- Struck by Image of sick child on TV
- Being moved by story in newspaper
- Random thoughts that "I can" do it
- Random thoughts that "I should" do it

West, R. and T. Sohal (2006). "Catastrophic" pathways to smoking cessation: findings from a national survey. *BMJ* 332(7539): 458-60.

Table 2. Success rates of planned and unplanned quit attempts

	Smokers and ex-smokers: 6 months to 5 years before* (n=281)		Smokers and ex-smokers: 6-12 months before* (n=191)		Current smokers: 6 months to 5 years before* (n=291)	
	Lasted <6 months†	Total % (95% CI)	Lasted <6 months†	Total % (95% CI)	Lasted <6 months†	Total % (95% CI)
Unplanned	66.4 (59.0 to 73.1)	45.0 (39.0)	30.0 (27.6 to 32.4)	33.0 (30)	38.1 (34.4 to 41.7)	39.0 (35)
Planned	42.3 (37.0 to 47.6)	54.2 (49.1)	28.6 (26.3 to 30.4)	64.4 (61.2)	20.6 (18.6 to 22.9)	60.4 (56.6)

\*Most recent attempt to stop smoking (percentage (95% confidence interval).

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## Does Health Education Cause Harm?

### STUDY PARAMETERS

- 659 problem drinkers
  - ❖ General population sample (n=239)
  - ❖ Treatment sample (n=420)
- Assessed 1-, 3-, and 5-years post-baseline

At 1-year follow-up, respondents were asked whether they were drinking 'a lot more', 'a lot less' or 'about the same' as the year before. If they were drinking 'a lot less' they were read a list of potential reasons, which were placed in random order:

1. you decided that your drinking was causing you health problems
2. you decided that you hit rock bottom with your drinking
3. you had a traumatic experience
4. **you weighed the pros and cons of drinking**
5. you were affected by seeing someone drunk or high
6. someone you knew quit or reduced their drinking
7. your doctor warned you to stop or cut down
8. your spouse or partner warned you to stop or cut down
9. you had a major change in your life-style, such as in your job, family or personal life
10. **you had a religious or spiritual experience.**

Matzger, H., L. A. Kaskutas, et al. (2005). Reasons for drinking less and their relationship to sustained remission from problem drinking. *Addiction* 100 (11): 1637-46.

## Does Health Education Cause Harm?

Table 2. Logistic regression analyses of remission from problem drinking (did not meet problem drinker criteria at any follow-up).

	General population sample (n=239)		Treatment sample (n=420)	
	OR	(95% CI)	OR	(95% CI)
<b>Demographic measures</b>				
Age (versus 25 or under)				
26-39	3.22	(1.41-7.37)	0.93	(0.39-2.24)
40+	0.85	(0.33-2.38)	3.28	(0.92-11.67)
Ethnicity (versus white)				
African-American	3.64	(1.11-11.69)	†	
Hispanic	2.66	(1.11-6.34)	†	
Other	1.99	(0.58-6.78)	†	
Income (versus <\$25 000)				
>\$25 000	2.48	(1.12-5.47)	†	
<b>Severity measures</b>				
AA attendance at T2	0.18	(0.01-1.04)	†	
Dependence Score	†		0.81	(0.74-0.88)
ASI psychiatric score	†		0.02	(0.00-0.07)
<b>Reasons for drinking less</b>				
Hit rock bottom	4.35	(1.12-16.85)	1.92	(1.06-3.49)
Traumatic event	2.66	(1.09-7.07)	2.16	(1.19-3.92)
Weigh pros and cons	0.44	(0.22-0.91)	0.40	(0.22-0.72)
Saw someone else drink or high	†		3.63	(0.28-1.14)
Doctor warning	†		0.50	(0.28-0.89)
Spouse/partner warning	0.17	(0.05-0.58)	†	
Spiritual/religious experience	2.94	(1.05-8.21)	2.36	(1.36-4.08)

Matzger, H., L. A. Kaskutas, et al. (2005). Reasons for drinking less and their relationship to sustained remission from problem drinking. *Addiction* 100 (11): 1637-46.

Journal of Consulting and Clinical Psychology 2007, Vol. 75, No. 2, 168-176		Copyright 2007 by the American Psychological Association 0893-3200/07/\$12.00 DOI: 10.1037/0893-3200.75.2.168	
<b>Sudden Gains in Cognitive Therapy of Depression and Depression Relapse/Recurrence</b>			
Tony Z. Tang Northwestern University		Robert J. DeRubeis University of Pennsylvania	
Steven D. Hollon Vanderbilt University		Jay Amsterdam University of Pennsylvania	
Richard Shelton Vanderbilt University			

## Sudden Gain

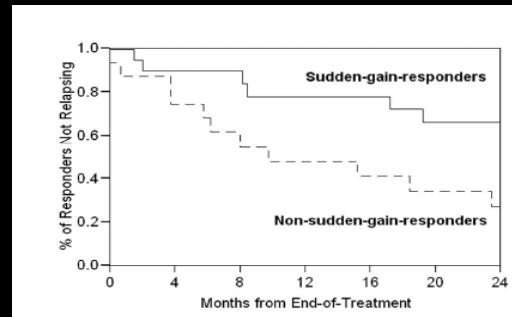
- 7 BDI points (Beck Depression Inventory), Between Session n and Session n+1, and
- At least 25% of the pre-gain session's BDI score (relative magnitude), and
- Difference between the mean BDI score of the three sessions before the gain (n-2, n-1, and n) and the three sessions after the gain (n+1, n+2, and n+3) was at least 2.78 times greater than the pooled standard deviations of these sessions' BDI scores

- 60 moderately-to-severely depressed adult outpatients who scored 20 on the 17-item modified HRSD.
- A full course of CT usually produces about 12–15 points of improvements in mean BDI scores, and 7 points is about half of that.

## RESULTS

- 24 of the 60 CT patients (40%) experienced sudden gains during treatment, with 8 patients experiencing more than one sudden gain. The sudden gains averaged 11 BDI points in magnitude, and the median session for them to occur was Session 5.

## Relapse by Sudden-Gain Status



1. Hardy GE, Cahill J, Siles WB, Ipson C, Mccaskill N, Barkham M. Sudden gains in cognitive therapy for depression: a replication and extension. *Journal of Consulting & Clinical Psychology* 2005;73(1):59-67.
2. Hofmann SG, Schutz SM, Meuret AE, Moscovitch DA, Suvak M. Sudden gains during therapy of social phobia. *Journal of Consulting & Clinical Psychology* 2006;74(4):687-97.
3. Kelleit S. The treatment of dissociative identity disorder with cognitive analytic therapy: experimental evidence of sudden gains. *Journal of Trauma & Dissociation* 2005;6(3):55-81.
4. Kelly MA, Cytarowski JM, Frank E. Sudden gains in interpersonal psychotherapy for depression. *Behaviour Research & Therapy* 2007;45(11):2563-72.
5. Kelly MA, Roberts JE, Bottonari KA. Non-treatment-related sudden gains in depression: the role of self-evaluation. *Behaviour Research & Therapy* 2007;45(4):737-47.
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7. Present J, Crits-Christoph P, Connolly Gibbons MB, et al. Sudden gains in the treatment of generalized anxiety disorder. *Journal of Clinical Psychology* 2008;64(1):119-26.
8. Siles WB, Leach C, Barkham M, et al. Early sudden gains in psychotherapy under routine clinic conditions: practice-based evidence. *Journal of Consulting & Clinical Psychology* 2003;71(1):14-21.
9. Tang TZ, DeRubeis RJ. Sudden gains and critical sessions in cognitive-behavioral therapy for depression. [see comment]. *Journal of Consulting & Clinical Psychology* 1999;67(6):894-904.
10. Tang TZ, DeRubeis RJ, Beberman R, Pham T. Cognitive changes, critical sessions, and sudden gains in cognitive-behavioral therapy for depression. [comment]. *Journal of Consulting & Clinical Psychology* 2005;73(1):168-72.
11. Tang TZ, DeRubeis RJ, Hollon SD, Amsterdam J, Shelton R. Sudden gains in cognitive therapy of depression and depression relapse/recurrence. *Journal of Consulting & Clinical Psychology* 2007;75(3):404-8.
12. Tang TZ, Luborsky L, Andrusyna T. Sudden gains in recovering from depression: are they also found in psychotherapies other than cognitive-behavioral therapy? *Journal of Consulting & Clinical Psychology* 2002;70(2):444-7.
13. Vittengl JR, Clark LA, Jernst RB. Validity of sudden gains in acute phase treatment of depression. [comment]. *Journal of Consulting & Clinical Psychology* 2005;73(1):173-82.

We have imposed a linear paradigm on a quantum phenomenon

- Fear, control, directiveness, external persuasion create wave interference.
- Competing neurologic processes
- Prefrontal Cortex ----- Limbic
- Discou

## Quantum Change

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**Quantum Change: When Epiphanies and Sudden Insights Transform Ordinary Lives**  
 William R. Miller and Janet C' de Baca, 2001

"Quantum Change is a vivid, surprising, benevolent, and enduring personal transformation. Some quantum changes are insightful, an "aha!" that leaves a person breathless and confident of a new truth and a new way of thinking. Other quantum changes are mystical, like Saint Paul's on the road to Damascus. Both kinds tend to impart a mysterious and enduring sense of peacefulness. Both mark the beginning of lasting and often pervasive changes in a person's life. Both usually involve a significant alteration in how one perceives other people, the world, oneself, and the relationships among them. What differentiates the mystical type is the sense of being acted upon by something outside and greater than oneself."

"Buried in the statement "I just decided", however can be another kind of experience that has been confused with ordinary decision making. It is the insightful type of quantum change. When people talk about such experiences in shorthand, they may say "it just happened" or "I just decided". Inquire a little more closely, however, and it becomes apparent that the process is somewhat more complex." (page37)

## Sensitivity to Initial Conditions

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An early pioneer of the theory was Edward Lorenz whose interest in chaos came about accidentally through his work on weather prediction in 1961. Lorenz was using a computer to run weather simulations. He wanted to see a sequence of data again and to save time he started the simulation in the middle of its course. He was able to do this by entering a printout of the data corresponding to conditions in the middle of his simulation which he had calculated last time.

To his surprise the weather that the machine began to predict was completely different to the weather calculated before. Lorenz tracked this down to the computer printout. The printout rounded variables off to a 3-digit number, but the computer worked with 5-digit numbers. This tiny difference, Lorenz discovered, produced large changes in the long-term outcome.

## The Butterfly Effect

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The flapping of a butterfly's wings in Malaysia can create a tornado in Kansas.

The butterfly flapping its wings represents a "small" change in the initial condition of the system which causes a chain of events leading to large-scale phenomena like tornadoes. Had the butterfly not flapped its wings, the trajectory of the system might have been vastly different.



- Due to variation in initial conditions, behavior change patterns are highly variable.
- Despite some common “pathways”, each behavior change journey differs.

## Two-Way Complexity

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- Individual State
  - A,B,C,D,E
    - ❖ A = Happy
    - ❖ B = Anxious
    - ❖ C = Angry
    - ❖ D = Apathetic
    - ❖ E = Sad
- Intervention Content
  - Facts 1,2,3,4,5

## Path Dependence

### Change can only occur if.....

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- State = Happy
- “Sticky” Fact Sequence =4,5,1,3,2
  
- State=Sad
- “Sticky” Fact Sequence =3,4,1,2,5

## Now add...

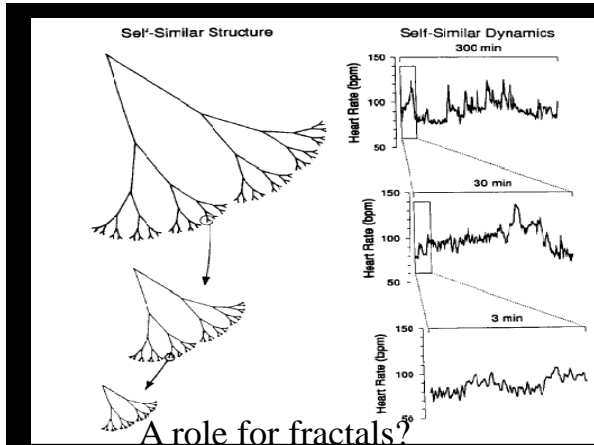
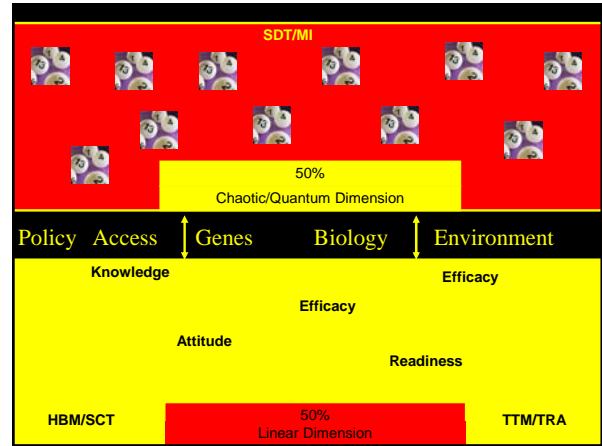
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- Environment
- Genetics
- Physiologic State
- Social Norms
- Prior Behavior
- Religion
- Etc.....

What do we get?...

COMPLEX PATHWAYS TO CHANGE





## Role of Fractals

- Identify Common Patterns of Change
  - Growth Curves
- Identify Audience Segments
  - Signal Detection
  - Cluster Analysis

## Implications of Chaos and Complexity for Behavior Change: Prepare and Spin

1. Prime individuals so that when **positive** chaotic events occur the **appropriate knowledge, attitude, and skills are present**
  - Create atmospheric conditions for the perfect storm
  - Prepare the ground in case a seed blows by
2. Encourage "wing flapping"
  - Accept the power of small inputs
  - Provide multiple opportunities to spin the balls
    - ◊ Episodic Intervention
      - Chronic Disease Management
    - ◊ Vary Condition
      - Times, days, moods
  - Create epiphanies
    - ◊ Motivational Interviewing

## A Quantum View of Motivational Interviewing

The goal is to facilitate fully informed, deeply contemplated, and internally motivated choices, not necessarily to change behavior.

To create epiphany

To consider the possibility of change. Over and over.

## Questions/Implications of Complexity and Chaos for Behavior Change

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- Do quantum events influence health behaviors beyond addiction ?
- Is non-linearity equally relevant to initiation, action, maintenance ?
- Distinguish types of motivation
  - Qualitative methods
  - fMRI
  - Add Linear/Quantum motivation assessment to study protocols
- Close the Black Box: Rethink predictability of behavior change
  - Accept the Random Component of change
  - Rethink Mediation/Moderation upper limit
  - Drop the search for magic main effects
- Rethink Linear Modeling of Behavior Change.
  - % Variance
  - Mediation
  - NON LINEAR aspects of behavior more than a nuisance or error term
- Reconsider replication studies
  - Lyapunov exponent
  - Studies are sensitive to initial conditions
  - Implications for RE-AIM
- Don't Shoot the Messenger