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Change is not always linear: The study of nonlinear and discontinuous patterns of change in psychotherapy[☆]

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Abstract

The study of discontinuities and nonlinear change has been a fruitful endeavor across the sciences, as these shifts can provide a window into the organization of complex systems and the processes that are associated with transition. A common assumption in psychotherapy research has been that change is gradual and linear. The research designs and statistics used to study change often reflect this assumption, but some recent research reveals other patterns of change. We briefly review relevant literature on dynamical systems theory and on life transition and post-traumatic growth to highlight the significance of nonlinear and discontinuous change across areas of psychology. We describe recent applications of these ideas and methods to the study of change in psychotherapy and encourage their use to complement more traditional clinical trial designs.

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Some change can be gradual and incremental, but many systems in nature show periods of turbulence and instability, with dramatic changes or growth spurts. Ilya Prigogine, a Nobel laureate known for his theory of dissipative structures in chemistry, argues that instabilities play an important role in transformation and that “most of reality, instead of being orderly, stable, and equilibrated, is seething and bubbling with change, disorder, and process” (Prigogine & Stengers, 1984, p. xv). The study of discontinuities has been a fruitful endeavor across the sciences, as these shifts can provide a window into the organization of a system and the processes that are associated with transition.

A common assumption in psychotherapy research is that change is gradual and linear. The research designs and statistics used to study change often reflect this assumption. The hypothesized predictors of change are measured once or twice and then compared between groups or correlated with symptom change at the end of treatment. Most research also focuses on group averages, with much less emphasis on the rich information available in individual time course

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data. Few studies include analyses of intra-individual variability, which traditionally has been viewed as “noise” or error (Collins & Sayer, 2000). Yet, as Collins (2006) has recently noted, some theoretical models propose a distinct point at which change accelerates, decelerates, or levels off, and temporal designs of longitudinal studies need to take these patterns into account. Traditional pre-post designs provide only snapshots of the change process, and traditional correlational and ANOVA-based analyses are limited in the extent to which they can capture such discontinuities (Nowak & Vallacher, 1998). Psychotherapy researchers can move beyond these constraints by collecting different kinds of data and using analytic strategies that capture the fluctuation and dynamics of change.

We begin with a brief overview of aspects of dynamical systems, life transition, and post-traumatic growth research to illustrate the importance of capturing a type of change that is nonlinear and can reveal system dynamics. We then describe recent applications of these ideas and methods to the study of change in psychotherapy.

1. Dynamical systems theory

Nonlinear dynamical systems theory is revealing important principles of pattern formation and change across scientific disciplines and across systems as diverse as cells, neurons, and even political systems (Thelen, 1995). Most generally, a dynamical system is a set of elements that interact and continually evolve over time (Vallacher, Read, & Nowak, 2002). To study change, researchers often conduct perturbation experiments. In this work, the variables of interest are assessed frequently across the trials of the experiment. The baseline homeostasis and stability of a system is measured, and then the system is disturbed and can be observed in transition. During transition, the organization of the system becomes apparent, as do the factors that facilitate and inhibit change (Kelso, 1997; van Geert, 1998).

The perturbation studies in dynamical systems research have revealed that an important predictor of transition is a type of discontinuity called *critical fluctuations* (Bak & Chen, 1991; Kelso, 1997; Schiepek, Eckert, & Weihrauch, 2003; van der Maas & Molenaar, 1992). When challenges to the current steady state of a system are too great to assimilate, change often is not gradual and linear but rather is characterized by sudden disturbance and increased variability in system behavior before reorganization. During this period of fluctuation, the system is destabilized but also open to new information and to the exploration of potentially more adaptive associations and configurations. There is then an oscillation between old patterns that are less viable and new patterns that are emerging, until the system settles into a new dynamically stable state (attractor) and variability decreases (Kelso, 1997; Thelen & Smith, 1994).

In their introduction to a special series on variability and infant development, van Geert and van Dijk (2002) review the work of a group of developmental psychologists who have used the dynamical systems framework to study developmental transitions. A consistent finding in this literature too is that periods of increased variability precede a range of developmental transitions, including motor, cognitive, and linguistic development, as well as emotional behavior. Another special series on dynamical systems in personality and social psychology includes studies that illustrate the important role of variability in cognitive and affective dynamics, interpersonal and group dynamics, and personality dynamics (Vallacher et al., 2002). Thus, evidence is accumulating to suggest that a period of critical fluctuation can be used to identify points of system transition. When these points of transition have been identified, researchers can study what is changing and the factors that catalyze this change.

2. Life transformation and adversarial growth

Psychologists interested in dramatic life changes or transformations study discontinuous change in the context of naturalistic perturbations. This work has clear application to the study of change in psychotherapy, an endeavor that also is designed to facilitate important life changes by creating disturbance. There is evidence that naturally occurring traumatic events and major life challenges can cause significant emotional distress and shake up a person's worldview. Such perturbations can develop into post-traumatic stress disorder (PTSD), dissipate and allow for a return to baseline functioning (Bonanno, 2004), or act as a catalyst for significant and often dramatic life transition, called *adversarial* or *post-traumatic growth* (Baumeister, 1991; Linley & Joseph, 2004; Tedeschi & Calhoun, 2004).

In a summary of research on post-traumatic growth, Tedeschi and Calhoun (2004) describe a process whereby some individuals can positively reinterpret, make meaning of adversity, and after a period of destabilization and distress, be transformed by their struggles with traumatic life events. When this type of nonlinear change was identified, subsequent research was conducted to describe what was happening during this period. Growth appeared across five domains: 1) a greater appreciation of life and a shift in priorities, 2) more intimate relationships with others, 3) a greater

sense of personal strength, 4) recognition of new possibilities or paths for one's life, and 5) spiritual development. Other research on narrative accounts of traumatic events revealed two essential components of adversarial growth: affective engagement and cognitive processing of the challenge (King, Scollon, Ramsey, & Williams, 2000; Pals & McAdams, 2004; Pennebaker, 1997).

Another line of work on discontinuous change in the context of life transition involves an accumulation of dissatisfaction with one's current circumstances that results in a dramatic shift in functioning. Miller and colleagues (Miller, 2004) are conducting field work on individuals with long histories of substance abuse who report discontinuous and transformational change related to their recovery. These authors describe a phenomenon that they call "quantum change," which is sudden and profound and affects a wide range of behaviors by creating an enduring and "deep shift in core values, attitudes, or actions" (Miller & C'de Baca, 2001, p.258). This change is often preceded by disturbance in the form of profound loss, prolonged distress, and even a point of desperation or hitting bottom. Witkiewitz and Marlatt (2007-this issue) are finding that the process of relapse in recovered substance abusers is very similar to the quantum change descriptions of recovery in that relapse is also sudden and discontinuous. This pattern of relapse is conveyed by the commonly used phrase "falling off the wagon" (Miller, 1996).

In his studies of people who have experienced life transformations, Baumeister (1994) has identified a potentially related phenomenon called "crystallization of discontent." This is a period of distress and dissonance that precedes a significant life change. He describes a process whereby incongruent and potentially disturbing information and experiences can be dismissed or minimized if they come from single events. In contrast, contradictory information from a number of events can accumulate to form a large pattern of negative, dissonant thoughts that can increase disturbance (crystallization of discontent) and serve as a catalyst for dramatic life changes (Bauer, McAdams, & Sakaeda, 2005; Baumeister, 1991). In a large sample of individuals who wrote narratives about their successful or failed life change experiences, Heatherton and Nichols (1997) documented an increase in disturbance before life transformations. Change was most likely to occur in the face of intense and enduring negative affect that culminated in a new perspective. Participants often reported a destabilizing negative event (or series of events) that increased unhappiness and motivation to make important life changes and modify one's core view of self.

The author of the popular book, *The Tipping Point* (Gladwell, 2000), describes similar processes of disturbance, critical threshold, and sudden discontinuous change. He applies these ideas to a broad range of social phenomena, such as the critical point at which a disease suddenly becomes an epidemic, a fashion becomes a trend, and the popularity of a new product spreads like wildfire. Some principles that are emerging from the study of transition outside of clinical psychology are that change can be discontinuous and that increased variability can be a marker of transition.

3. The study of discontinuities in psychotherapy

A number of theorists have suggested that the principle of destabilization before change described in other sciences might also apply to the process of change in psychotherapy (Bateson, 1979; Hager, 1992; Haley, 1971; Hayes & Strauss, 1998; Mahoney, 1991; Schiepek, Fricke, & Kaimer, 1992). Therapy provides a stable environment and increases patients' readiness and resources for change, but it also introduces a variety of interventions to interrupt, challenge, and destabilize old patterns. Thus change in therapy can be gradual and linear, but also discontinuous and nonlinear. As in dynamical systems theory, discontinuous transitions in therapy are hypothesized to be preceded by critical fluctuations and instabilities in the system's behavior (Schiepek et al., 2003).

The study of nonlinear change requires multiple assessments over time and the examination of the individual trajectories of variables rather than group averages. Although these methods are in one sense a new way of examining psychotherapy process, in another sense, they are a revival of the single-subject design that has had a long history in psychotherapy and behavior change research (Herson & Barlow, 1976; Kazdin, 1982; Molenaar, 1987). As the randomized control trial design gained prominence, psychotherapy research has moved from single-subject designs with individual data to pre-mid-post designs that have smoothed trajectories of grouped data and comparisons of grouped means (Laurenceau, Hayes, & Feldman, 2007-this issue). If the variables of interest are assessed frequently over the course of therapy, treatment processes can be examined to better understand what facilitates and inhibits change. Krause, Howard, and Lutz (1998) urged a return to the analysis of individual data: "in order to maximize relevance for clinical practice, the results of treatment research should always be reported at this most disaggregated or individual change level" (p. 838). Individual time course data can facilitate movement beyond the question of *whether* change occurs and toward an understanding of *how* change occurs (Barkham, Stiles, & Shapiro, 1993).

Some research has revived the method of studying individual trajectories to uncover nonlinear patterns and points of discontinuity within the clinical trial design. The examples presented below illustrate the useful information that can be gleaned from an examination of weekly or biweekly data from individual time course data. Patterns of symptom change can then point to segments of therapy to study more closely to reveal the process of change. We review examples of recent research on nonlinear change in anxiety disorders, depression, personality disorders, and substance abuse.

3.1. Anxiety disorders

A number of theoretical orientations emphasize the importance of increasing emotional arousal to induce change in therapy (for reviews see Greenberg, 2002a; McNally, 2007-this issue; Samoilov & Goldfried, 2000; Whelton, 2004). Exposure-based therapies apply this principle directly in that they are based on the assumption that anxiety must be increased to ultimately reduce it. The relevant fear structure must be activated with an adequate level of affective arousal and then new information incompatible with the original structure is introduced (Foa & Kozak, 1986; Foa, Huppert, & Cahill, 2006). Emotion-focused experiential therapy also targets emotions directly to increase arousal and facilitate processing and therapeutic change (Greenberg, 2002b). This combination of emotional arousal and cognitive analysis is strikingly similar to the descriptions of post-traumatic growth and life transition described earlier. This change process is also likely to be associated with a period of fluctuation, marked by transient periods of symptom exacerbation.

Consistent with this, Heimberg and Becker (2002) describe three patterns of anxiety ratings during in-session exposures in social anxiety that are associated with improvement. One pattern, the “steady decline” is gradual and linear, whereas the “spike” and “habituation curve” capture a brief period of symptom exacerbation that is discontinuous and curvilinear. Nishith, Resick, and Griffin (2002) examined the shape of change over the course of therapy in a sample of women with rape-related PTSD who received two empirically-supported therapies — prolonged exposure or cognitive-processing therapy. These authors used curve estimation techniques to examine whether a linear or curvilinear pattern best described the course of symptom reduction in the therapies. The curvilinear function provided the best fit for total PTSD symptom reduction for both types of therapy, which again suggests that anxiety increases before it decreases.

Gilboa-Schechtman and Foa (2001) examined three-month patterns of natural recovery following sexual and non-sexual assault. They quantified five characteristics of emotional reaction using individual trajectories of symptoms over 12 weeks: 1) severity at initial assessment, 2) peak severity (defined as strongest reaction over the 12-week period), 3) delay of peak severity (defined as earliest occurrence of the peak severity), 4) rate of decay after the peak, and 5) severity of the reaction at final assessment. The early peak reaction predicted recovery from sexual assault trauma, whereas delayed peak reaction predicted greater severity of later PTSD. These findings suggest that a period of heightened symptoms soon after the trauma facilitates the recovery process, even without therapy.

3.2. Depression

Three types of discontinuous change have been identified and predict symptom improvement in cognitive-behavioral therapies for depression. Ilardi and Craighead (1994) identified an *early rapid response* pattern that is characterized by a substantial decrease in depression symptoms by session four, after which change levels off. The rapid response pattern first identified in depression has also been found to predict improvement across a number of other clinical disorders, such as panic disorder (Penava, Otto, Maki, & Pollack, 1998), bulimia (e.g., Grilo, Masheb, & Wilson, 2006), alcohol abuse (Breslin, Sobell, Sobell, Buchan, & Cunningham, 1997), and in mixed populations (Crits-Christoph et al., 2001).

Tang and DeRubeis (1999) identified another pattern of change in the early sessions of cognitive therapy for depression that they call “*sudden gains*.” The sudden gain is a large improvement during a single between-session interval that does not reverse. Although plots of averaged symptom change at pre-, mid-, and post-treatment suggested gradual and linear change, Tang and colleagues (Tang & DeRubeis, 1999; Tang, DeRubeis, Beberman, & Pham, 2005) found that plots of individual time course data revealed that about 39% to 46% of patients experienced a sudden gain and that this nonlinear pattern predicted improvement in depression. Sudden gains also have been associated with better functioning in the end of treatment in supportive-expressive therapy (Tang, Luborsky, & Andrusyna, 2002),

nonmanualized psychotherapies in routine clinical practices (Stiles et al., 2003), systematic behavioral family therapy (Gaynor et al., 2003), and CBT for recurrent and atypical depression (Vittengl, Clark, & Jarrett, 2005).

Our research group has identified another discontinuous pattern of change that we call a “*depression spike*”. In an exposure-based cognitive therapy for depression that we are developing (Hayes, Beevers, Feldman, Laurenceau, & Perlman, 2005), hierarchical linear modeling (HLM) analyses revealed an overall S-shaped (cubic) trajectory of symptom change on the Modified Hamilton Rating Scale for Depression (MHRSD; Miller, Bishop, Norman, & Maddever, 1985). Individual trajectories revealed a rapid response pattern (as defined by Ilardi & Craighead, 1994) early in therapy. The exposure phase of therapy was characterized by depression spikes, which were large increases in depression during this phase of therapy followed by a decrease in symptoms. The depression spike is the conceptual opposite of the sudden gain and is similar to the anxiety spike pattern described in exposure-based therapies for anxiety disorders (Heimberg & Becker, 2002). Patients were classified as having a rapid response or not and a depression spike or not. Both of these patterns of change predicted more improvement in depression at the end of treatment, after controlling statistically for previous levels of depression (Hayes et al., *in press*). Fig. 1 illustrates the rapid response and depression spike patterns.

These three patterns of change (rapid response, sudden gain, and depression spike) are discontinuous and nonlinear and therefore would not be apparent in pre-post analyses of group data. Yet, they mark important transition points that can reveal what therapists are doing to facilitate this transition and what is changing in patients during this time. Without such markers, the researcher is left to examine all of the sessions and weeks of data to identify predictors of change, to randomly select sessions, or to select sessions from phases of therapy without regard to symptom change.

The research described below illustrates how markers of transition can be used to guide further process analyses. For example, Tang and DeRubeis (1999) examined the hypothesis that cognitive change facilitates the sudden gain in cognitive therapy for depression. They studied sessions from randomized clinical trials of cognitive therapy that had already been conducted. They found that patients reported more cognitive changes in the session that immediately preceded the gain (pregain session) than in the control session, which they considered the one that immediately preceded the pregain session (prepregain session). This provided a starting point for researchers to then examine whether the sudden gain occurred in other therapies and clinical problems, and whether other processes might predict the sudden gain in noncognitive therapies (e.g., Tang et al., 2002).

In an open trial of an exposure-based cognitive therapy for depression, our research group found that both the rapid response and depression spike patterns occurred and predicted improvement in depression (Hayes et al., *in press*). These transition points were then used to guide further analyses of the process of change. Patients wrote narratives each week over the course of therapy, so the narratives in the vicinity of the rapid response and also during the height of the depression spike could be studied for a given individual. Consistent with Ilardi and Craighead’s (1994) hypothesis that the rapid response is associated with changes in hope, the narratives sampled from this period were characterized by more hope for rapid than for nonrapid responders. We also hypothesized that more cognitive/emotional processing would occur in the exposure phase of therapy, which included the activation of the depressive network, an increase in

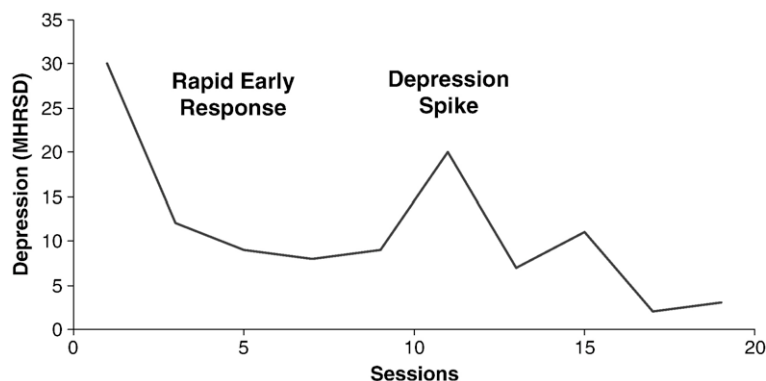


Fig. 1. Modified Hamilton Rating Scale for Depression (MHRSD) scores for case example administered biweekly across the course of therapy. This case illustrates the early rapid response and depression spike patterns.

arousal (depression spike), and corrective information (Foa & Kozak, 1986; Foa et al., 2006). As predicted, those who experienced a depression spike wrote narratives during this period with more cognitive/emotional processing (a significant shift in perspective and emotional response) than those without a spike. This research sets the stage for a more stringent investigation of the process of change in a randomized clinical trial with a comparison group that is likely to produce a more linear pattern of change.

3.3. *Personality disorders*

Another example of identifying a discontinuity to guide the study of change is our research on cognitive therapy for avoidant and obsessive–compulsive personality disorders. Therapy in this open trial occurred over 52 weeks, and patients rated the therapeutic alliance every fifth session. This assessment schedule allowed for the examination of individual trajectories of alliance ratings to reveal a discontinuity called alliance rupture and repair episodes. A V-shaped pattern (cf. Stiles et al., 2004), characterized by a worsening in the alliance followed by an improvement, significantly predicted improvement in personality disorder symptoms and depression, even after controlling statistically for earlier symptom change and alliance ratings (Strauss et al., 2006). This marker of change can now be studied more closely to reveal what therapists are doing during this period and what is changing in patients. We can also study what is happening when ruptures occur that are not repaired but instead are associated with attrition or worse outcomes.

Similar to our findings of a discontinuous period of symptom exacerbation in our depression trial (Hayes et al., *in press*), hierarchical linear modeling analyses also revealed a cubic pattern of distress (symptoms of depression and anxiety) over the course of this cognitive therapy for personality disorders. Higher ratings of cognitive/emotional processing during this period of increased distress predicted more improvement in symptoms of personality disorder, depression, anxiety, and positive functioning at the end of therapy. These relationships remained statistically significant, even after controlling for symptom change immediately before the period of distress (Hayes, Feldman, Cardaciotto, & Laurenceau, *in preparation*). Here again, zeroing in on a period of discontinuous change revealed an important predictor of change.

3.4. *Substance abuse*

An area that has received little attention is the process of change after the acute phase of therapy. This period is typically viewed as relatively smooth, and researchers assess the maintenance of treatment outcomes at intervals of several months. However, Dimeff and Marlatt (1998) remind clinicians and researchers that the road to recovery from substance abuse is anything but smooth. Witkiewitz and Marlatt (2007-*this issue*) propose that researchers and clinicians in this area have not predicted relapse well because of the reliance on linear, continuous models of relapse. More often seemingly minor changes in risk factors (e.g., negative affect) can set off a rapid cascade of increased craving, positive outcome expectancies, drug-seeking behavior, and relapse. They argue that it is rare that after recovery a person returns to pretreatment levels of substance abuse at a rate proportional to the change in the relevant risk factors. The process is instead discontinuous and, as previously noted, aptly described as “falling off the wagon.”

This conception of relapse is consistent with a branch of dynamical systems theory called catastrophe theory, which focuses on the study of sudden discontinuous change in a behavior resulting from slight continuous changes in the system parameters (Thom, 1975). Witkiewitz and Marlatt (2007-*this issue*) review empirical studies that demonstrate nonlinear patterns of substance use behavior in natural settings. They examine in their own work whether catastrophe modeling better predicts relapse after recovery than linear models. Hufford, Witkiewitz, Shields, Kodya, and Caruso (2003) applied catastrophe theory models of sudden and discontinuous change, called *cusp catastrophes*, and demonstrated that the shift from recovery to relapse is indeed better predicted by nonlinear than linear models of change. In a subsequent study described in this issue, Witkiewitz and Marlatt (2007-*this issue*) replicated the Hufford et al. (2003) study with a larger sample size, a longer follow-up period, and a more sophisticated method of catastrophe cusp-fit modeling. In that study, two cusp catastrophe models again provided a better fit to the observed data than did the linear and logistic models. By identifying the point of transition, these models can be applied to identify distal and proximal risk factors that predict relapse. This method might be applied fruitfully to the study of relapse in anxiety, depression, and perhaps other disorders.

4. Conclusion

Although change can happen in a gradual and linear way, there is increasing evidence across disciplines that it can also occur in discontinuous and nonlinear ways. This latter type of change is often preceded by an increase in variability and a destabilization or loosening of old patterns that can be followed by system reorganization. In post-traumatic growth, life transition, and psychotherapy, destabilization often occurs in the context of emotional arousal which, when accompanied by emotional processing and meaning-making, seems to contribute to better outcomes.

The study of transition points, marked by discontinuities in individual symptom trajectories, can guide researchers to the segments of therapy likely to reveal factors that mobilize and inhibit change and to client change processes. These methods provide a finer degree of resolution than pre-post designs and can reveal predictors, moderators, mediators, and mechanisms of change. These strategies can be included in open trial designs and in the randomized clinical trial. This type of process research is a vital part of treatment development.

The empirically-supported therapy treatment movement has set out to identify “what works for whom.” The ideas and methodologies described in this article offer the possibility of enriching this work to better understand the “when,” “how,” and “why” of change (Paul, 1967).

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