SOCIALDYNAMICS
Journal of Social Complexity
Vol.2 No.1, October 2004, pp. 33-49

Group Chaos Theory (GCT)
A research model and analysis of group process

EDIL TORRES RIVERA
University of Buffalo, SUNY
Christopher Baldy Hall 409, Buffalo, NY, USA
etrivera@buffalo.edu

Abstract
This article provides a different perspective to group process research based on: (a) the incorporation of theoretical concepts from chaos and mathematical theory to group process, (b) discovery oriented research using a single-case study design, (c) time-series data collected on the group variables of trust, belongingness, cohesiveness, and synergy over the life-span of single case groups, (d) mathematical analysis of group process data, and (e) the case study presentation of results in terms of mathematical derivatives and functions, phase space portraits, bifurcations and attractors, close return and Poincaré maps, and power spectrum analysis and histograms.

Fuhriman and Burlingame (1994) indicated that, in the analysis of small group process over the past two decades, two broad definitional categories have resulted: (a) process as phenomena and (b) process as interaction (see Hulse-Killacky, Kraus, & Schumacher, 1999). Studies that focus on process as phenomena describe some aspect or characteristic of the member, leader, or group behavior (Burlingame & Fuhriman,1997; Fuhriman, Drescher, & Burlingame, 1984), such as therapeutic factors, reciprocity, cooperation, etc. Descriptions of group process as phenomena also can be found in investigations of process in counseling and therapy groups, as well as in task and psychoeducation groups (Fuhriman & Burlingame, 1994). Researchers also have begun to suggest that we focus on group process in terms of transactions, activity over time, and directional change (Greenberg & Pinsof, 1986; Rice & Greenberg, 1984), as well as consideration of interaction as temporal form, the interactive context of process, and the existence of multiple factorial influences (e.g., individual, interpersonal, or the group as a whole) that occur instantaneously and over time (Fuhriman & Burlingame, 1994). Likewise, Fuhriman and Burlingame (1994) suggest these considerations "force us to confront the inherent complexity of small group process – a complexity inherent in a dynamic, open, interdependent, and nonlinear system" (p. 503).

> "Chaos theory attempts to understand complexity: complexity that is born of nonlinearity, interdependence...; complexity that involves the mixing of 'symmetry with asymmetry, predictable periodicity with unpredictable variation' (Hayles, 1990, p. 51), order with disorder. Chaos is the phenomenon that manifests itself over very long time frames. ... The holistic nature of complex systems demonstrates that

everything has the potential to affect everything else. This increases our awareness of interrelationships and unpredictability. The study of wholeness and change is the science of chaos. ... These characteristics are strikingly similar to the various descriptions of the dynamics of small group process, and thus an application of the methodology of chaos theory to the study of small groups appears not only appropriate, but fruitful" (Fuhriman & Burlingame, 1994:504-5).

The purpose of the present article is to provide a different perspective to group process research based on: (a) the inter-disciplinary incorporation of theoretical concepts from chaos and mathematical theory, (b) discovery oriented research using a single-case study design (Elliott, 1984; Hill, 1990; Mahrer, 1988; Werstlein & Borders, 1997), (c) time-series data on the group process phenomena of trust, belongingness, cohesiveness, and synergy over the life-span of a single-case group, (d) mathematical analyses of group process, and (e) the results presented in terms of mathematical derivatives, phase space portraits, bifurcations, and attractors.

Two case studies will be presented to demonstrate mathematical modeling techniques and the application of chaos theory to measure group processes. Research questions related to group "process" as phenomena were the following:

1. Do group members' perceptions of the occurrence of the group process variables of trust, belongingness, cohesiveness, and synergy change from group session to group session and over the life-span of the group?
2. At what points in the life of the group do group members' perceptions of the occurrence of the group process variables of trust, belongingness, cohesiveness, and synergy change most prominently?
3. Based upon group members' perceptions of the occurrence of the group process variables, what is the relationship and interaction among the group process variables of trust, belongingness, cohesiveness, and synergy from session to session and over the life-span of the group?

1. Case Study I

1.1. Method

A single-case study was designed to assess group counseling students' perception of the occurrence of the group process phenomena of trust, belongingness, and cohesiveness from group session to group session and over the life-span of a group process course (14 weeks). First year master's degree students were enrolled in a 48-semester-hour, at a large northeastern state university. Students' perception of the occurrence of trust, belongingness, and cohesiveness were assessed in a time-series format at the end of each of 11 group session meetings.

A discovery oriented research procedure was selected (Elliott, 1984; Hill, 1990; Mahrer, 1988) because, "Discovery-oriented research is viewed as a necessary first step in the systematic inquiry of phenomenon, with the goals of describing what is actually happening and then generating hypotheses for future study" (Werstlein & Borders, 1997:122). Similar to Werstlein and Borders' (1997) research approach, a single subject case study design was used to allow intensive assessment and examination of the nonlinear variables of trust, cohesiveness, and belongingness. "The single subject design, involving multiple process variables, provided the clearest means to 'describe the group, specify changes in the behaviors or actions of the group over time, and link one or more selected variables... .(Heppner, Kivlighan, & Wampold, 1992:320)' " (as cited in Werstlein & Borders, 1997).

1.2. Participants

The single-case study design consisted of 14 counselors-in-training who were enrolled in a first-semester group process course, all of which volunteered for the study. The sample was one of convenience. The group counseling course was the first group class taken in the counseling program curriculum. Due to the experiential nature of the group course, member performance in the course was evaluated (graded) as Satisfactory or Unsatisfactory (S or U). Although group member participation was the primary requirement, class members were also required to read Gladding's (1999) textbook and write a final, unstructured course paper concerning group process. If the overall group process course was to be classified into a group type, using the ASGW (2000) training standards and classification system for groups, the course would be placed in the "psychoeducational group" category: "Educational groups that teach group participants knowledge and skills for coping adaptively with potential and/or immediate environmental challenges, developmental transitions, and life crises" (ASGW, 1992:13).

However, the format of the course followed a highly structured model that is well established and researched and is used in the training and supervision of counselors: the Structured Group Supervision (SGS) model (Betz, Morris, Wilbur, & Roberts-Wilbur, 1997; Betz, Wilbur, & Roberts-Wilbur, 1981; Phan, 2001; Wilbur, Roberts-Wilbur, & Betz, 1981; Wilbur, Roberts-Wilbur, Hart, Morris, & Betz, 1994; Wilbur, Roberts-Wilbur, Morris, Hart, & Betz, 1991). Group participants were required to read published articles concerning the SGS model of group training and supervision. Based on the format and structure of the SGS model, group members were not required to function in one group type only (i.e., task, psychoeducational, or counseling group) and the leader made adjustments in facilitation to accommodate the direction and focus of the group, and the group type, again based on the SGS model, as it emerged within each session and from session to session. Participants' ages ranged from 22 to 49 (M = 27.4, SD = 8.2). All 14 participants were female and Caucasian.

The group met weekly for one academic semester (14 weeks) with each group session being two and one-half hours in length. Data were not collected after the first session, as that meeting focused on the course introduction, syllabus, and requirements. Data also were not collected during the week of Thanksgiving recess nor after the last group meeting, which was devoted for feedback and course evaluations.

1.3. Variables and Procedure

Following DeLucia-Waack (1997) critical research criteria and to address this study research question regarding group process variables or phenomena, the selection of the group variables of trust, belongingness, and cohesiveness was not arbitrary. Rather, our assessment of the variables was based upon our own and others' group work and theorizing with these variables (Betz et al., 1981; Budman, Soldz, Demby, Davis, & Merry, 1993; Butler & Furhriman, 1983; Fuhriman, Drescher, Hnason, & Henrie, 1982; Lieberman, Yalom, & Miles, 1973; MacKenzie, 1990; MacKenzie & Livesley, 1983; Stone, Lewis, & Beck, 1994; Wilbur et al., 1981; Yalom, 1995).

For example, the definition of trust merge ideas from Budman et al. (1993), MacKenzie and Livesley (1983), MacKenzie (1990), and Yalom's (1995) notions of group norms, culture building, and altruism. Similarly, our definition of belongingness, and universality; and Horowotz, Rosenberg, Baer, Ureno, and Vallasenor's (1988) concepts of interpersonal skill, affiliation, interpersonal relations, and "closeness to other." Perhaps more obvious cohesiveness was defined in terms of Yalom's (1995) "groupness," "weness," and "attractiveness."

Consequently, the purpose of our variable selection and procedures was to explore patterns and changes in the group process variables of trust, belongingness, and cohesiveness within a single session, between sessions, and over the entire length of the group using rating and coding schemas similar to those discussed by Fuhriman and Barlow (1994). Therefore, trust, belongingness, and cohesiveness served as the group's initial conditions, or the initial starting values depicted in a series of nonlinear equations and mathematical functions (Hoppensteadt, 2000).

1.4. Rating Form and Data Collection

At the end of each group-class session, the group members were asked to complete a simple rating form on which they rated on a five point Likert-type scale (with five being the highest rating and one being the lowest rating) their perceptions of the level of trust, belongingness, and cohesiveness for that session. The rating form consisted of one typed page, on which the three group process variables were listed in the order of trust, belongingness, and cohesiveness. Directions stated: "Please respond to the following group variables, based upon your experience of this group session, by circling the number that best indicates/describes your perception of these group variables during this group session. A five (5) indicates the highest level of each group variable and a one (1) indicates the lowest level of each group variable." Trust was: "Defined in terms of members' genuineness, authenticity, congruency, and honesty; and the predictability of group members' behaviors." Belongingness was: "Defined in terms of members 'fitting in' with the group; shared commonalties among group members; and members being an integral part of the group". Cohesiveness was: "Defined in terms of emotional closeness among members; members' caring and empathy toward each other; and members' positive regard for what others feel, think, and do."

Major changes have been established to occur in process dimensions (such as trust, belongingness, and cohesiveness) from one session to the next (MacKenzie & Livesley, 1988), it was determined that the rating form needed to be sufficiently short to administer after each group session, and that it was most appropriately administered after every session rather than as a post-group assessment. This is commonly referred to as "time-series" data collection (Abraham, Abraham, & Shaw, 1990; Guastello, 1987; Lorenz, 1963). The data collected were based on group members' perceptions (see DeLucia-Waack, 1997) and the five-point, Likert-type scale was an unstandardized, self-report measure (Bednar & Kaul, 1994) — with all the limitations of a "homemade, investigator-generated coding system" (Burlingame, Kircher, & Taylor, 1994:64, as cited in Riva & Smith, 1997).

Although we do not discount the importance and necessity of using group work measures with established reliability and validity, our purpose and method was to explore the complex occurrences and changes in three group variables, or initial conditions to be used in nonlinear equations and mathematical functions. This purpose seemed better served by the researchers homemade assessment and coding schema. Also, because we did not know whether or not the five-point Likert-type scale was sensitive enough to show changes between sessions, maximizing a Type 2 error (retaining a null hypothesis of no changes between sessions when changes actually existed) seemed the most conservative and reasonable risk.

Yalom (1995), points out there are many methods of measuring cohesiveness and other group variables. Our homemade method of assessment may be characterized as a coding schema (Burlingame et al., 1994; Fuhriman & Barlow, 1994) to assess members' perceptions of the study's group variables, rather than a true assessment instrument (see DeLucia-Waack, 1997). DeLucia-Waack (1997) also indicated that members' perceptions of what it feels like to be in a group are important aspects of group climate and "therapeutic" or "curative" group variables or factors, as suggested by Yalom (1995).

At the completion of data collection for the 11 group sessions, the 14 group participants' ratings for each of the group variables for each of the 11 group sessions were tabulated and means for each group variable for each group session were computed. The means of each group variable for each of the 11 group sessions were then used as the data set for mathematical analysis.

1.5. Analysis

Because our data analysis procedures were based upon chaos theory and mathematical methods, rather than positivistic-scientific assumptions and statistical procedures, it is necessary to review some critical aspects of both chaos theory and our mathematical methods prior to presenting the study results. For example, when there is a time-dependency of the variables involved, (as these are in this case study) researchers use time-series data to measure the value of variables. Phase space diagrams are used to show the time-dependence of two or more variables, while maintaining the time relationship of the variables. To be able to show the interaction between the variables involved, graphs of the variables are drawn in a phase space diagram that has a directional component corresponding to the development of the interaction with regard to time. That is, a graph or phase space diagram is mathematically generated that corresponds to the interaction among variables with regard to time.

The mathematically generated phase space diagram may then be analyzed for the existence of attractors. An attractor is a pattern that forms in the interaction of variables, providing mathematical and qualitative information about the time-varying properties of the variables involved. The phase space diagrams of the time-series data set for the variables trust, belongingness, and cohesiveness were mathematically analyzed for the existence of fixed-point, periodic, chaotic, and quasiperiodic attractors in the time-varying properties of these variables.

A fixed point attractor is one in which all data points are at one point, or end up at one point. A fixed point attractor thus corresponds to a homeostatic, or constant, position of the variables. A periodic, limit-cycle attractor is one in which the variables (or data points) change in a predictable, or periodic, repetition. Similar to a fixed point attractor, the position of the variables or data points are homeostatic, except in a periodic attractor it is a time-varying homeostasis that corresponds to the repetition of the variables in a predictable manner. Thus, attractors such as fixed point and periodic, limit-cycle attractors may provide predictability (or order) to a dynamic system in terms of the system's points of homeostasis. A chaotic attractor corresponds to an unpredictable time variation of variables. There is no homeostasis, as in the fixed point and periodic attractors, and the variables change rapidly with no periodicity or repetition. Finally, a quasi-periodic attractor is an attractor between periodic and chaotic attractors that is believed to represent a pattern, or path, of variable interaction that leads to chaos among the variables.

As well as being concerned with the patterns (order) that form within data, a nonlinear and mathematical analysis of data also looks for departures from these patterns — an illustration of a phase space representation known as a bifurcation, or cusp in mathematical terms (Hoppensteadt, 2000). That is, when two or more variables form an attractor there is an interaction of the variables in terms of opposites — the oppositional nature of two or more variables forming an attractor. A bifurcation is a point in a dynamic system where the system becomes unstable or discontinuous, and the point of equilibrium is unstable. The slightest movement causes the point of equilibrium to move to a new point and to seek a different equilibrium. In other words, a bifurcation point in nonlinear dynamical systems indicates a phase space transition between two different dynamical regimes. A bifurcation also may be found if an unordered system spontaneously evolves into an ordered state (self-organization). That is, a bifurcation may describe a system's movement from the order of an attractor (one regime, equilibrium) to disorder (another regime, instability or disorder), and vice versa.

1.6. Mathematical Functions.

To describe certain mathematical functions, and to quantitatively analyze what the phase space diagram of a mathematical function is portraying, specific mathematical terms are typically used to explain turning points in the graphs of mathematical functions. The application of these terms to maxima and minima problems is also well known in economics, engineering, and the physical sciences. These terms are likewise classified as the derivative of a mathematical function, a concept as old as Newton and Leibnitz. The concept of a derivative is also an extension from Euclidean geometry.

Of particular importance to the present study, however, is the case where the derivative of a particular function is not continuous, or discontinuous: a bifurcation, or cusp in mathematical terms (see Wilbur et al., 1999). The cusp is really the simplest example of a function, that is continuous and has a continuous derivative, except at a single point where it is not continuous. The cusp function is a very dramatic example of the discontinuity of the function. On one side of a point, for example, the curve is headed in one direction, say down, but at the cusp (or bifurcation) the derivative changes directions abruptly and so dramatically that on the other side of the cusp, the derivative is headed in the other direction (up), in the opposite direction it was going before the cusp or bifurcation point. Mathematically, the derivative of the function is given by the formula:

$$g'(t) = f'(t)/h'(t)$$

Thus, a parametric function will have a cusp in the mathematical sense if the derivative is discontinuous at a point, and the curve has the same concavity on each side of the discontinuity. For the function *g*, which has the parametric representation above, this can only happen if the denominator of the expression is zero, or both functions $h'(t)$ and $f'(t)$ have a zero at some point t_0. The search for cusps of the function *g* then reduces to looking for zero points of the functions that occur in the parametric representation of the derivative (see Wilbur et al., 1999).

To this point, all of our discussion has focused upon two-dimensional phase space representations. In three-dimensions, however, the derivative of the function **g** has the components:

$$(f'(t)/N(t),\ g'(t)/N(t),\ j'(t)/N(t))$$

where

$$N(t) = (((f'(t))^2 + ((h'(t))^2 + ((j'(t))^2)^{1/2}.$$

Using this expression for three-dimensional phase space representations, a function will again have a cusp in the mathematical sense if the derivative is discontinuous at a point, and the curve has the same concavity on each side of the discontinuity. For the function *g* which has the parametric representation above, this can only happen if the denominator of the expression is zero, or if $f'(t)$, $h'(t)$ and $j'(t)$ have simultaneous zeroes at the same point t_0.

Prior to using the above mathematical analyses of data, however, a polynomial curve was first fit to the points corresponding to the means of each of the three study variables (trust, belongingness, and cohesiveness) for each of the eleven weekly, group meetings. The least squares polynomial interpolation method, using MATHEMATICA™, provided a mathematical expression that fit the mean values of each study variable for each group session exactly at the mean point and allowed for interpolation of the mean values between the mean points, i.e., curves. Phase space portraits were then drawn, using MATHEMATICA™, in two- and three-dimensional parametric graph representations.

1.7. Results

Two-dimensional phase space diagrams for the nonlinear interaction of: a) cohesiveness and trust, b) cohesiveness and belongingness, and b) belongingness and trust are shown, respectively, in Figures 1, 2, and 3 (see Figures 1, 2, and 3). Figure 4 displays the nonlinear interaction of trust, belongingness, and cohesiveness in three-dimensions (see Figure 4). From a qualitative perspective of visual inspection, points of interest in the analysis of the phase space portraits are the sharp cusps (bifurcations) that result. These cusps are points in the group where the group process variables became unstable or discontinuous, the points where equilibrium was unstable. In other words, these cusps may be bifurcation points in the nonlinear group variables that indicate a phase space transition between two different dynamical regimes (see Wilbur et al., 1999). In other words, the cusps may describe bifurcations of the group variables' movement from order (equilibrium) to disorder (instability), or vice versa (self-organization).

In addition to the visual inspection and qualitative analysis of the phase space diagrams, the mathematical and quantitative analysis for cusps (bifurcations) in a two-dimensional phase space involved searching for simultaneous zeroes of the derivatives in the expression $g'(t) = f'(t)/h'(t)$. Furthermore, because each of the interpolation polynomials for the variables of trust, belongingness, and cohesiveness has a specific formula calculated by MATHEMATICA™, it was possible to obtain the specific formula for the derivatives of each of the variables trust, belongingness, and cohesiveness. That is, MATHEMATICA™ provided the quantitative analysis of these derivatives and numerically solved the equations for the zeroes of the expressions for the parametric derivatives.

For research question one, using the polynomial interpolation of means, the results revealed by the mathematical analyses and phase space diagrams demonstrate that group members' perceptions of the occurrence of the group dynamic variables of trust, belongingness, and cohesiveness do change from group session to group session and over the life-span of the group (see Figures 1-4). The phase space diagrams graphically exhibit these qualitative changes, while the results of the mathematical analyses results also describe quantitative changes related to research question one, as well as research question two.

In terms of research questions one and two, the numerical and quantitative analyses and solutions showed that for the variables belongingness and cohesiveness there were simultaneous zeroes of the derivatives for each of the functions belongingness and cohesiveness at two points $\{t_0 = 1.29$ and $t_0 = 5.90\}$ (see Figure 2). Thus, in the two-dimensional phase space diagram of the variables belongingness and cohesiveness, there were bifurcations (cusps) between the 1st and 2nd group sessions and between the 5th and 6th group sessions. Similarly, for the variables trust and cohesiveness there were simultaneous zeroes of the derivatives for each of the functions trust and cohesiveness at two points $\{t_0 = 8.33$ and $t_0 = 9.63\}$ (see Figure 1). Therefore, in the two-dimensional phase space diagram of the variables trust and cohesiveness, there were bifurcations (cusps) between the 8th and 9th group sessions and between the 9th and 10th group sessions. The mathematical analyses and solutions in two-dimensions additionally showed a single bifurcation (cusp) of trust and cohesiveness, belongingness and cohesiveness, and belongingness and trust between the 10th and 11th group sessions $\{t_0 = 10.71\}$ (see Figures 1, 2, and 3, respectively). In three-dimensions as well, the mathematical analyses showed that at $t_0=10.71$ the denominator of the expression $(f'(t)/N(t), g'(t)/N(t), j'(t)/N(t))$, where $N(t) = (((f'(t))^2 + ((h'(t))^2 + ((j'(t))^2)^{1/2}$, vanished and there was a cusp in the phase space diagram for the three variables trust, belongingness, and cohesiveness between group sessions 10 and 11 $\{t_0=10.71\}$ (see Figure 4).

These results indicate that the points at which group members' perceptions of the occurrence of the group process variables of trust, belongingness, and cohesiveness changed most prominently were between group sessions 1 and 2 and 5 and 6 (for belongingness and cohesiveness), between group sessions 8 and 9 and 9 and 10 (for trust and cohesiveness), and between sessions 10 and 11 (for trust and cohesiveness, belongingness and cohesiveness, and belongingness and trust). Therefore, in regard to research question three, and group members' perceptions of the occurrence of the group process variables and the relationship and interaction among the group process variables, the results indicated that: a) bifurcations of belongingness and cohesiveness occurred between sessions 1 and 2, 5 and 6, and 10 and 11; b) bifurcations of trust and cohesiveness occurred between sessions 8 and 9, 9 and 10, and 10 and 11; and c) bifurcations of trust and belongingness occurred between sessions 10 and 11.

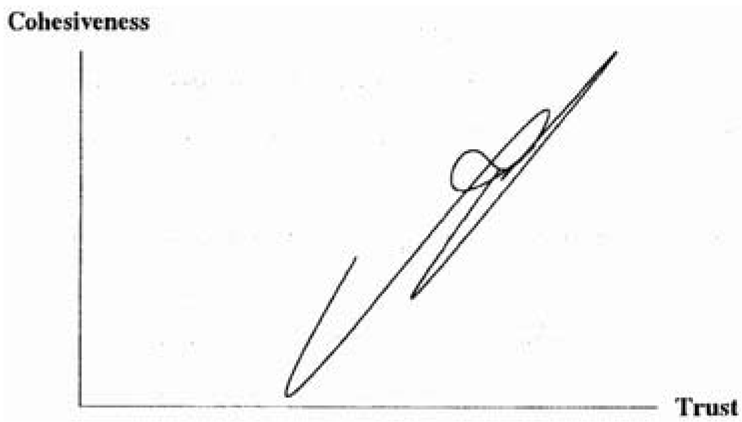

Figure 1
Two-dimensional phase space diagram of initial conditions trust and cohesiveness

In addition, the group appeared to be forming an interaction attractor of trust, belongingness, and cohesiveness between sessions 2 and 5. From sessions 6 and 8, trust was still attempting to remain as the attractor, while belongingness and cohesiveness were attempting to form their own attractor, moving in the same direction at two points (between sessions 3 and 5 and between sessions 6 and 10), but in opposition to trust. As discussed earlier, these changes and departures (bifurcations) in interactional patterns (attractors) would indicate the oppositional nature of two or more variables forming an attractor and that the equilibrium (order) of the group became unstable, discontinuous, and unordered. Furthermore, between sessions 5 and 6 belongingness and cohesiveness bifurcated from each other; between sessions 8 and 9, 9 and 10, and 10 and 11 cohesiveness bifurcated from trust; between session 10 and 11 belongingness bifurcated from trust; and between sessions 10 and 11 all three variables bifurcated from each other.

In summary, the t_0 points found in the mathematical data analyses and study results revealed the quantitative bifurcation points of this dynamical, nonlinear group; while the group variable attractors are graphically and qualitatively displayed in the phase space diagrams (see Figures 1-4). For four of the eleven sessions (i.e., from sessions 2 to 5) belongingness, trust, and cohesiveness were forming an attractor in interaction. From sessions 6 to 8, trust was still attempting to remain as the attractor, while belongingness and cohesiveness were attempting to form their own attractor, moving in the same direction at two points (between sessions 3 and 5 and between sessions 6 and 10), but in opposition to trust. That is, the apparent attractor being formed before session 8 of the group was abandoned and the attractor was destroyed. Thus, the resulting cusps or bifurcation points.

These results would fit Abraham's (personal communication, May, 13, 1997) description of a subtle bifurcation, in which an attractor appears, disappears, or undergoes a change — at which point it is no longer an attractor — to cross it means abandoning the attractor in order to pass to a new attractor. A more liberal interpretation of the results would suggest a catastrophic bifurcation of the group variables, in which an attractor (order) simply disappears (F. Abraham, personal communication, May 13, 1997) (Sastry, 1999). Finally, as indicated by Fuhriman and Burlingame (1994), identifying the

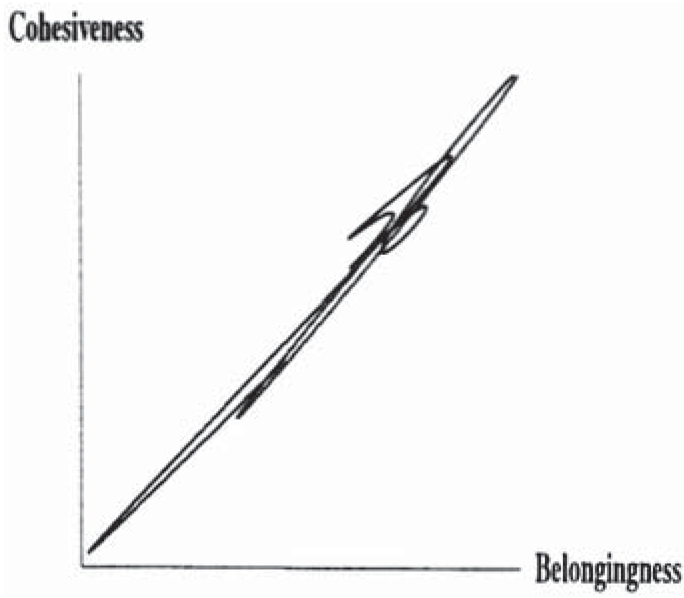

Figure 2

Two-dimensional phase space diagram of initial conditions belongingness and cohesiveness process that precipitates change in a group is critical. And, as discovered by Prigogine and Stengers (1984), when a stability threshold is reached in a system a bifurcation occurs. That is, through the iteration of the group variable interactions in the present study, a repeating and stabilizing process was created among the group variables of trust, belongingness, and cohesiveness between sessions 2 and 5, and for the variable trust between session 6 and 8. However, between sessions 5 and 6, 8 and 9, 9 and 10, and 10 and 11 this iterating, repeating, and stabilizing process between sessions 2 and 5 and 6 and 8 reached a size and point at which a choice was created and a subtle or catastrophic bifurcation occurred. The variables within the group were changed and symmetry was broken, irreversibly changing the group as a whole. This process is the essence of a chaotic system and the stability (attractors) or instability (bifurcations) residing in it (Fuhriman & Burlingame, 1994).

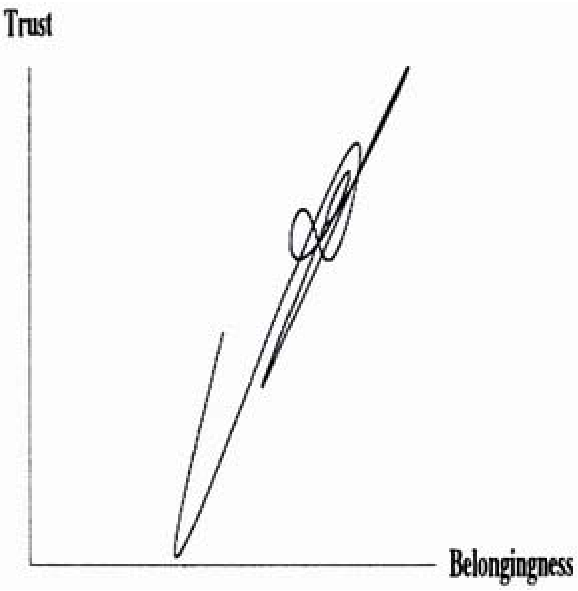

Figure 3
Two-dimensional phase space diagram of initial conditions belongingness and trust

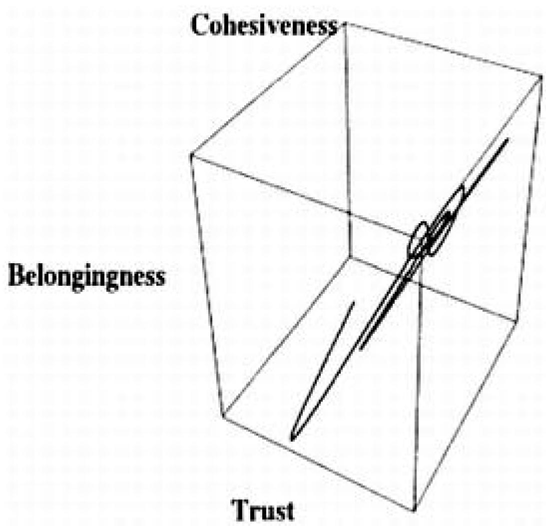

Figure 4
Three-dimensional phase space diagram of initial conditions trust, belongingness, and cohesiveness

2. Case Study II

2.1. Method and Participants

The same discovery oriented research procedure used in case study one also was used in the second case study, along with the single-case study design. The participants in the second case study, however, were 7 master's-level students who were enrolled in a second-year group supervision course (practicum) and who volunteered for the study. All course members volunteered for participation. The 7 practicum students had completed a minimum of 24 semester-hours of credit in a 48 semester-hour, master's degree program in counseling at a large state university in the Northeast. As in case study one, the sample was one of convenience, as the study participants were not pre-screened or randomly selected for inclusion in the study group. The group supervision course was the third group course taken in the counseling program curriculum by each of the 7 participants. The completion of two, first-year group courses was a prerequisite to enrolling in practicum, in addition to other curricular requirements. Participants' ages ranged from 23 to 30 (M = 25.7, SD = 2.29). All participants were Caucasian: 3 females and 4 males.

The group met weekly for 30 weeks (two academic semesters; one academic year) with each group supervision session being two and one-half hours in length. Although the life-span of the group was 30 sessions, members' perceptions of the occurrence of the group process variables were collected at the end of each of 27 group sessions. During the first semester, data were not collected after the first session, as that meeting focused on the course introduction, syllabus, and requirements. Data also were not collected during the week of Thanksgiving recess (fall semester) nor during the week of spring break (spring semester).

2.2. Rating Form, Data Collection, Variables, and Procedure

The rating form, the variables and variable definitions, the data collection and tabulation procedures, the computation of each variable mean for each group session, and the procedural format for the course in the second case study remained the same as in the first case study, with only a few exceptions. At the end of 27 of the 30 group supervision sessions, the group members were asked to complete the same rating form, with the same five-point, Likert-type rating scale, concerning their perceptions of the occurrence of the group process variables. In the second case study, however, a fourth group process variable of group synergy was added to rating form variables and definitions of trust, belongingness, and cohesiveness. Synergy was defined in terms of members' willingness to subjugate personal and individual interests and needs for the best interest and welfare of the entire group, similar to Betz et al. (1981) and Yalom's (1985, 1995) notions of group energy, versus individualism. Finally, the group and course format used was the Structured Group Supervision model, the same procedure as in case study one, except that it was applied for 27 group sessions in case study two, versus 11 group sessions in case study one.

2.3. Analysis

As in case study one, the same research questions were posed, polynomial approximations were fit to the means of each group variable for each group session, and phase space diagrams and derivatives of the mathematical functions were generated by MATHEMATICA™. The same formulas as in case study one were used to explore bifurcations and attractors in the interaction of the four group process variables during each group session and over the life-span of the group.

2.4. Mathematical Functions.

In case study two, however, the close returns test and return maps, Poincaré maps, and power spectrum analysis and histograms were also used to analyze the time-series data set (see Wilbur et al., 1999). The close returns test, in particular, searches a strange attractor for periodic orbits, which are unstable. Strange attractors also are characterized by an abundance of different periodicities — such as that demonstrated in the logistic equation (see Wilbur et al., 1999), a well known example from the biological sciences (Gleick, 1987). Thus, for the major focus of case study two, a computational algorithm and MATHEMATICA™ code for the analysis of close return maps (see Wilbur et al., 1999) was applied to each of the functions for the four study variables (Gilmore, 1995; Marion & Weaver, 1997). This mathematical analysis was accomplished by fitting a Fourier Sine and Cosine series to the points corresponding to the means of each of the variables for each of the 27 weekly meetings of the group. This Fourier Series method, using MATHEMATICA™, gives a mathematical expression that fits the values of the variables exactly at the point (i.e., mean) and allows for interpolation of values between the points (i.e., means). This approximation allows enhancement of the return maps. That is, between each of the measured values (means) for each of the group variables, additional data points were obtained by using the Fourier series functions to interpolate between the measured values of each of the variables. This provided a total of 297 points for the time-series data set of each group variable. This was enough to see the general form of the return map.

A further analysis, known as the Poincaré map (see Wilbur et al., 1999), was also performed on the data set of each group variable. This analysis amounts to taking a cross-section of the forming attractor in phase space. For a simple period attractor, the Poincaré map is simply two points. The sequence of points forming the Poincaré map in the case of a quasiperiodic attractor, however, lies on a closed curve, and is easy to discern from the spread of points in the Poincaré map for a strange attractor (Tufillaro, Abbott, & Reilly, 1995:177). Because the contour shape of the present study's return maps indicated the presence of quasiperiodicity in each of the graphs (Gilmore, 1995:389), an additional mathematical method called power spectrum analysis (see Wilbur et al., 1999) also was used to examine the hypothesis that the data sets were quasiperiodic (Tufillaro, Abbott, & Reilly, 1995). Finally, due to the small number of terms in the power spectrum analysis, a histogram analysis of the incidence of close return "hits" was conducted (see Wilbur et al., 1999) to summarize the occurrence of close returns in the time-series data sets (Tufillaro et al, 1995:177). Thus, for each of the group variables, the histogram of "hits" for the range of data points in the time-series from 0 to 150 was plotted. Gilmore (1995) indicates that for chaotic data, the histogram will contain a series of sharp peaks, more or less evenly spaced.

2.5. Results

The results of the second case study investigations were promising, but, due to the number and complexity of analyses performed, they are difficult to detail in the allotted space. Therefore, representative findings of case study two will be presented to demonstrate the potential of chaos and mathematical modeling techniques for group research. As in case study one, a polynomial curve was fit to the points corresponding to the means of each session for each of the four study variables, and the least squares polynomial method allowed for the interpolation and consequent analysis for cusps or bifurcations (see Wilbur et al., 1999).

In regard to research question one, findings again indicate — as in case study one — that members' perceptions of trust, belongingness, cohesiveness, and synergy do indeed change from session to session and over the life-span of the group. These findings are based on the analysis of polynomial derivatives for cusps, the equations for zeros of the expressions for the parametric derivatives and the close return maps. In response to research question two, for the variables belongingness and cohesiveness, a cusp or bifurcation occurred between sessions 9 and 10; for trust and cohesiveness, cusps occurred between session 4 and 5, 14 and 15, and 22 and 23; for belongingness and trust, cusps occurred between sessions 17 and 18, and 26 and 27; for synergy and belongingness, cusps likewise occurred between sessions 17 and 18, and 26 and 27; for synergy and cohesiveness, cusps occurred between sessions 9 and 10, and 12 and 13; and for synergy and trust, cusps occurred between sessions 2 and 3, and 16 and 17. As in case study one, the cusps would suggest, at minimum, the subtle bifurcation of an attractor among the group process variables; or perhaps a catastrophic bifurcation, in which an attractor simply reappears or disappears (Abraham, personal communication, May 13, 1997).

In regard to research question three, and in both case studies one and two, an attractor involving all group process variables appeared to form early in the group process. More specifically, the attractor formed between sessions 2 and 5 in case study one (over 11 group sessions) and between sessions 5 and 9 in case study two (over 27 group sessions). Also similar in both case studies, there appeared to be the formation of an attractor at about the mid-point of the group's life. Again more specifically, an attractor formed between sessions 6 and 8 in case study one (over 11 sessions) and between sessions 10 and 12 for case study two (over 27 sessions). The group life in case study one ended at 11 sessions, and a bifurcation also occurred between sessions 10 and 11, at the end of the group. Similarly, in case study two, in which the group was divided into two academic semesters, the attractor that formed between sessions 5 and 9 bifurcated between sessions 9 and 10, near the end of semester one.

Also similar to case study one's bifurcation at the end of the group's life of 11 sessions (between sessions 10 and 11), case study two likewise indicated a bifurcation at the end of the group's life of 27 sessions (between sessions 26 and 27). However, the attractor that formed between sessions 10 and 12 in case study two was also near the end of academic semester one and the beginning of semester two, which also may indicate the formation of an attractor early in the life of a group, if the second semester is viewed as a both a beginning point as well as a mid-point in the group's life. Considering the second semester of case study two (sessions 14-27), the same pattern in the formation of attractors that was observed in case study one and the first semester of case study two also occurred near the mid-point and the end of the second semester of the group process (between sessions 18 and 22, and between sessions 23 and 26). Thus, there was order and pattern in the group process variables of both case study one and two, occurring at the beginning and mid-points of each case study group.

In addition to this periodic order and pattern, however, graphs or plots of the close return maps for each of the four variables also revealed areas within each plot that exhibited connected curves that may be evidence of quasiperiodic behavior, of either a linear or nonlinear origin (see Figure 5 of the close return map for belongingness). In addition, the close returns displayed in the Poincaré maps for each of the four study variables (see Figure 6 of the Poincaré map for trust) likewise indicated both periodicity and quasiperiodicity of the data set for the group variables of trust, belongingness, cohesiveness, and synergy. The general form of the return maps was quite similar to that found by Gilmore (1995) and Marion and Weaver (1997), and the contours of the return maps were similar to those in the return map for the Roessler attractor and in one of the components of the Lorenz dynamical system (see Wilbur et al., 1999). That is, although there was insufficient evidence to positively conclude that chaos is present in the return maps (i.e., horizontal, straight lines) of the second case study, the Poincaré maps (see Figure 6) do show a distinctive and discernible difference from that of a periodic or quasiperiodic map and are quite similar to those found in known chaotic maps.

Therefore, in regard to research question three, and because the study's return maps indicated the presence of quasiperiodicity in each of the graphs, a power spectrum analysis was performed on the data sets and histograms were obtained. As a result, it may be stated definitively that there was evidence of a quasiperiodic relationship among the study variables, most probably of a nonlinear origin (see Figures 5 & 6), and despite the presence of order and pattern (attractors) in the data. A more liberal interpretation of the data and findings, as revealed in the histograms (see Figure 7, histogram for synergy) and in some cases of the close return maps (see Figure 5) and Poincaré maps (see Figure 6), would suggest chaotic behavior, or at least quasiperiodic behavior leading to chaos. When examined very closely, for example, there appears to be a pattern of horizontal, straight lines in the close returns maps (see Figure 5), which Gilmore (1995) states is evidence for the presence of unstable periodic orbits and characteristic of a strange (chaotic) attractor. Likewise, the histogram for chaotic data contains a series of sharp peaks, more or less evenly spaced (Gilmore, 1995). These results were also apparent in the present study's findings, as displayed in Figure 7 (see Figure 7, histogram for synergy).

In summary, findings of the second case study's time-series data revealed order and pattern (attractors) within the data, as well as quasiperiodic relationships, most likely of a nonlinear origin, between the group process variables of trust, belongingness, cohesiveness, and synergy. There also was evidence that the observed quasiperiodic behavior of the data set may be chaotic or, at minimum, may lead to chaos; although there is not sufficient evidence to establish, for certain, the presence of chaos in the group variables.

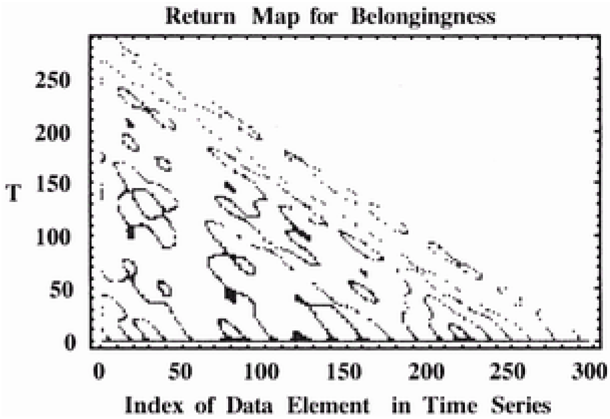

Figure 5
Close return map for the variable Belongingness from 297 data points in time series

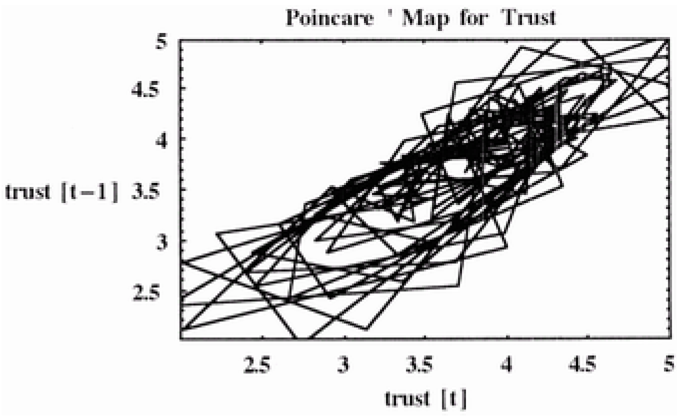

Figure 6
Poincaré map for Trust

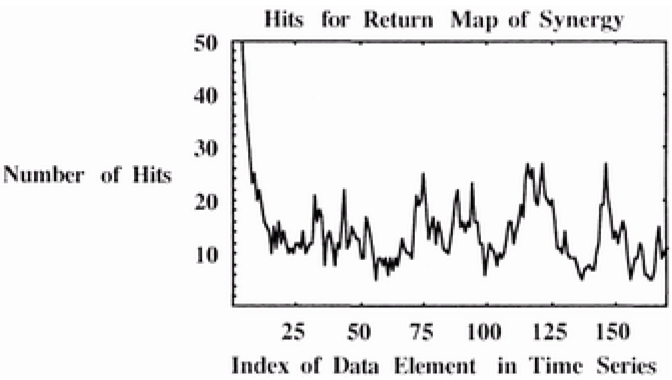

Figure 7
Hits for return map for Synergy; e=0.0355

3. Conclusions and Discussion

Because of the complexity and multidimensional nature of groups and group work (Bednar & Kaul, 1994; McClure, 1998), it is the dynamic and nonlinear aspects of group process that have posed difficulty for researchers (Riva & Kalodner, 1997). In addition, the current and static perspective of conducting group research and data analyses (Worchel, 1994) has resulted in the reliance on a single perspective in group work research (i.e., positivistic science and statistical procedures) as well as methodological and analysis problems (Riva & Smith, 1997).

Thus, in an attempt to address the complex, multidimensional, dynamic, and nonlinear properties of group process phenomena, the present study used a single-case study research design and a discovery oriented research procedure (Elliot, 1984; Hill, 1990; Mahrer, 1988; Werstlein & Borders, 1997). The intent of this systematic inquiry method was to describe what actually happens in groups and to generate hypotheses for future study (Werstlein & Borders, 1997), to investigate the predictable periodicity and unpredictable variation in group process, and to explore the wholeness and change inherent in the complexity of groups (Fuhriman & Burlingame, 1994). The results of our discovery oriented research indicate that polynomial approximations, mathematical derivatives and phase space diagrams, close return and Poincaré maps, and power spectrum analysis and histograms are promising and may proven to be useful procedures in the study and analysis of group research data. They appear to capture and describe the time-varying, dynamic, and nonlinear nature of group process phenomena as well as changes in group behavior and activity over time, directional change, interaction as temporal form, the interactive context of group process, multiple factor influences, and the linking of selected group variables (Greenberg & Pinsof, 1986; Heppner, Kivlighan, & Wampold, 1992; Rice and Greenberg, 1984).

This is also the unique contribution of the present research. As far as we know, no other studies of group process phenomena have used these mathematical functions, derivatives, and analyses to investigate and explore group process variables. Fuhriman and Burlingame (1994), for example, used standard parametric procedures, sequential analyses, and correlation integrals in their research of nonlinear group member interactions in a time-series format. Further, in terms of this study's findings, it would appear that the mathematical derivatives and phase space diagrams obtained for the group variables explored, were similar to classic and established examples of bifurcations and attractors in chaos theory and research in the biological and physical sciences (see Burlingame, Fuhriman, & Barnum, 1995; Gleick, 1987; Guastello, 1987; Wilbur, Frank-Saraceni, Roberts-Wilbur, & Torres Rivera, 1997a; Wilbur, Frank-Saraceni, Roberts-Wilbur, & Torres Rivera, 1997b; Wilbur, Kulikowich, Roberts-Wilbur, & Torres Rivera, 1995a; Wilbur, Roberts-Wilbur, Torres Rivera, & Kulikowich, 1995a).

Although speculative at this time, the cusps (bifurcations) found also may be modeling the swallowtail model of discontinuous change and equilibria (Guastello, 1987), or that of a catastrophic bifurcation of discontinuous changes, as discussed by Guastello (1987) and Abraham (personal communication, May 13, 1997). In addition to the discovery of classic mathematical cusps in the present study findings, the phase space portraits of the study's group variables also appear to be representative of established categories of attractors. For example, the "loops" portrayed in Figure 1, for trust and cohesiveness; in Figure 2, for belongingness and cohesiveness; and in Figure 3, for trust and belongingness may be categorized in terms of the classic periodic, limit-cycle attractor as well as the well known predator-prey attractor (see Wilbur et al., 1999). Again speculative, these same "loops" also may be representative of the initial formation of chaotic attractors in the study's group variables, similar to the famous butterfly or owl-mask attractor found by Lorenz (Lorenz, Malkus, Spiegel, & Farmer, 1963; Sparrow, 1982), and as presented in the phase space diagram of Figure 4. As indicated, there was evidence of quasiperiodic relationships among the study variables, most probably of a nonlinear origin, as revealed in the close return and Poincaré maps (see Figures 5 & 6) and the histograms (see Figure 7). The pattern of horizontal, straight lines in the close return maps (see Figure 5) also may be evidence for the presence of unstable periodic orbits which is characteristic of a strange (or chaotic) attractor (Gilmore, 1995). Likewise, the series of sharp peaks, more or less evenly spaced (see Figure 7), are contained in chaotic data (Gilmore, 1995).

3.1. Implications for Research

At minimum, the findings of the present study are encouraging. Similar to Fuhriman and Burlingame (1994), great complexity and variability of a nonlinear nature was found in the present study variables, even thought Fuhriman and Burlingame (1994) studied group process as member interactions while the present study explored process variables in terms of group phenomena (trust, belongingness, cohesiveness, and synergy). Nonetheless, our analysis produced mathematical, graphic models of the nonlinear patterns of order (attractors), bifurcation, and quasiperiodicity (perhaps chaos) in the group process variables studied. It would therefore seem reasonable to assume that chaos theory and mathematical modeling may provide methodology appropriate for studying the nonlinear, interdependent process that describes the function of a group as a whole over time. The application and extension of chaos theory and mathematical modeling also may increase our ability to identify nonlinear patterns of order and disorder in all group process. Finally, further investigations using chaos theory and mathematical modeling may be not only warranted but may provide an additional avenue to address the current shortcomings and pitfalls of group research (Fuhriman & Burlingame, 1994; Riva & Kalodner, 1997; Worchel, 1994).

3.2. Implications for Practice

If group process is indeed multidimensional, complex, dynamic, nonlinear, and disorderly as well as orderly (Bednar & Kaul, 1994; Dagley, Gazda, Eppinger, & Stewart, 1994; Riva & Kalodner, 1997; Riva & Smith, 1997), as supported in the results of the present study, this and future research may form a different basis for not only how group research is performed, but also for group work application and practice (see Wilbur et al., 1999). The present linear and sequential conceptualization of group process, for example, as progressing in a chronological series of group stages or phases may be valid in describing and facilitating groups. At best, perhaps the most we could hope for is general, yet unpredictable and nonlinear, patterns of order and disorder in the development of groups and group process.

If this is the case, group workers would be required to flexibly and innovatively respond to the group's movement from periods of stability (order and equilibrium) to discontinuity (disorder) and the emergence and destruction of various group cusps and attractor, some of which may be catastrophic and chaotic, and entirely unpredictable (Wilbur et al., 1995a, 1995b, 1997a, 1997b). It would no longer be acceptable to describe and facilitate groups with the use of prescriptive leader behaviors to insure the observation and occurrence of the appropriate group stage or phase of development. Then too, it may become necessary that group work researchers and practitioners be trained in mathematics and mathematical analyses, which are descriptive and explanatory of the naturally occurring phenomena of life, rather than continuing to be trained with the Cartesian and Eurocentric assumptions of positivistic-science and statistical procedures, which were developed and contrived to control, predict, and bring order to a world of natural phenomena (and groups) that are by definition and nature complex, multidimensional, dynamic, nonlinear, chaotic — and mathematical.

4. References

Abraham, F. D., R.H. Abraham, & C.C. Shaw. (1990). *A visual introduction to dynamical system theory for psychology*. Santa Cruz, CA: Aerial.

Association for Specialists in Group Work. (2000). *Professional standards for the training of group workers*. Retrieved November 2003 from the Association for Specialists in Group Work. URL: http://www.asgw.org/training_standards.htm

Association for Specialists in Group Work. (1992). *Professional standards for the training of group workers. Journal for Specialists in Group Work, 17*:12-19.

Bednar, R., & T. Kaul. (1994). 'Experiential group research: Can the cannon fire?'. In S L. Garfield & A. E. Bergin, (eds.)., *Handbook of psychotherapy and behavior change*:631-63. 4th ed. New York: Wiley.

Betz, R. L., J.R. Morris, M.P. Wilbur, & J. Roberts-Wilbur. (1997). 'Enhancing counselor effectiveness with structured group supervision'. *Journal of Michigan Counseling Association, 25*:5-12.

Betz, R. L., Wilbur, M. P., & Roberts-Wilbur, J. (1981). 'A structural blueprint for group facilitators: three group modalities'. *The Personnel and Guidance Journal, 60*:31-6.

Budman, S. H., S. Soldz, A. Demby, M.S. Davis, & J. Merry. (1993). 'What is cohesiveness: An empirical examination'. *Small Group Research, 24*:199-216.

Burlingame, G. M., & A. Fuhriman. (1997). 'Small Group Research and Dynamical Systems Theory: Conceptual and Methodological Considerations, a Reply to McGrath'. *Group Dynamics: Theory, Research, & Practice, 1*:28-31.

Burlingame, G. M., & A. Fuhriman, & K.R. Barnum. (1995). 'Group therapy as a nonlinear dynamical system: Analysis of therapeutic communication for chaotic patterns'. In F. D.. Abraham, & A.R. Gilgen, (eds.)., *Chaos theory in psychology*:73-86. Westport, CT: Praeger Publishers.

Butler, T., & A. Fuhriman. (1993). 'Level of functioning and length of time in treatment variables influencing patient's therapeutic experience in group psychotherapy'. *International Journal of Group Psychotherapy, 33*:489-504.

Coyne, R. K., & F.R. Wilson. (1998). Toward a standards-based classification of group work offerings. *Journal for Specialists in Group Work, 23*:489-504.

Dagley, J. C., G. M. Gazda, S.J. Eppinger, & E.A. Stewart. (1994). In A. Fuhriman & G. M. Burlingame, (eds.)., *Handbook of group psychotherapy: An empirical and clinical synthesis*:340-69). New York: Wiley.

DeLucia-Waack, J. (1997). 'Measuring the effectiveness of group work: A review and analysis of process and outcome measures'. *Journal for Specialists in Group Work, 22*:278-293.

Elliott, R. (1984). 'A discovery-oriented approach to significant event s in psychotherapy: interpersonal process recall and comprehensive process analysis'. In L. Rice & L. Greensburg, (eds.)., *Pattern and change*:503-27. New York: Guilford.

Fuhriman, A., & S.H. Barlow. (1994). 'Interaction analysis: Instrumentation and issues'. In R. R. Die & K. R. MacKenzie, (eds.)., *Advances in group psychotherapy: Integrating research and practice*:27-75). Madison, CT: International Universities Press.

Fuhriman, A., & G.M. Burlingame. (1994). 'Measuring small group process: A methodological application of chaos theory'. *Small Group Research, 25*:502-18.

Fuhriman, A., S. Drescher, & G.M. Burlingame. (1984). 'Conceptualizing small group process'. *Small Group Behavior, 15*:427-40.

Fuhriman, A., S. Drescher, E. Hanson, & R. Henrie. (1992). 'Refining the measurement of curatives: An empirical approach'. *Small Group Behavior, 17*:186-201.

Gilmore, C. C. (1995). 'A new test for chaos'. In R. R. Trippo, (ed.)., *Chaos and nonlinear dynamics in the financial markets*:383-416. Chicago, IL: Irwin Professional Publishing.

Gladding, S. T. (1999). *Group work: A counseling specialty.* 3rd ed. Upper Saddle River, NJ: Prentice-Hall.

Gleick, J. (1987). *Chaos: Making a new science*. New York: Viking Press.

Greenberg, L. S., & W.M. Pinsof. (1986). 'Process research: Current trends and future perspectives'. In L. S. Greenberg & W. M. Pinsof (Eds.), *The psychotherapeutic process: A research handbook*. New York: Guilford.

Guastello, S. J., (1987). 'A butterfly catastrophe model on organizations: Academic performance'. *Journal of Applied Psychology, 72*:165-82.

Heppner, P.P., D.M. Kivlighan, Jr., & B.E. Wampold. (1992). *Research design in counseling*. Pacific Grove, CA: Brooks/Cole.

Hill, C. E. (1990). 'Exploratory in-session process research in individual psychotherapy: A review.' *Journal of Consulting and Clinical Psychology, 58*:288-94.

Hoppensteadt, F. C. (2000). *Analyses and simulation of chaotic systems*. 2nd ed. New York: Springer.

Hulse-Killacky, D., K.L. Kraus, & R.A. Schumacher. (1999). 'Visual conceptualization of meetings: A group work design'. *Journal for Specialists in Group Work, 24*:113-24.

Lieberman, M., I. Yalom, M. Miles. (1973). *Encounter groups: First facts.* New York: Basic Books.

Lichtenberg, J.W., & P.L. Knox. (1991). 'Order Out of Chaos: A Structural Analysis of Group Therapy'. *Journal of Counseling Psychology, 38*:279-88.

Lorenz, E. N. (1963). 'Deterministic nonperiodical flow'. *Journal of the Atmospheric Sciences, 20*:130-41.

MacKenzie, K.R., & W.J. Livesley. (1983). 'A developmental model for brief group therapy'. In R. R. Dies, & K.R. Mackenzie, (eds.)., *Advances in group psychotherapy*:101-16). New York: International Universities Press.

Mahrer, A.R. (1988). 'Discovery-oriented psychotherapy research'. *American Psychologist, 43*:694-702.

McClure, B.A. (1998). *Putting a new spin on group: The science of chaos.* Mahwah, NJ: Lawrence Erlbaum Associates Publishers.

Phan, L.T. (2001). *Structured group supervision from a multicultural perspective.* Unpublished doctoral dissertation, University of Nevada, Reno.

Rice, L.N., & I.S. Greenberg. (1984). *Patterns of change: Intensive analysis of psychotherapy process.* New York: Guilford.

Riva, M.T. & C.R. Kalodner. (eds.). (1997). 'Group research: Encouraging a collaboration between practitioners and researchers [Special Issue]'. *Journal for Specialists in Group Work, 22,* (4).

Riva, M.T., & Smith, R. D. (1997). 'Looking into the future of group research: Where do we go from here?'. *Journal for Specialists in Group Work, 22*:226-76.

Sastry, S. (1999). *Nonlinear systems: Analysis, stability, and control.* New York: Springer.

Sparrow, C. (1982). *The Lorenz equations, bifurcations, chaos, and strange attractors.* New York: Springer.

Stone, M.H., C.H. Lewis, & A.P. Beck. (1994). 'The structure of Yalom's curative factors scale'. *International Journal of Group Psychotherapy, 44*:239-45.

Werstlein, P.O., & L.D. Borders. (1997). Group process variables in group supervision. *Journal for Specialists in Group Work, 22*:120-36.

Wilbur, M.P., J. Frank-Saracini, J. Roberts-Wilbur, & E. Torres Rivera. (1997a, September). 'A chaos model of group supervision process research'. *Paper presented at the meeting of the North Atlantic Regional Association of Counselor Educator and Supervisor, Plattsburgh, NY.*

Wilbur, M.P., J. Frank-Saracini, J. Roberts-Wilbur, & E. Torres Rivera. (1997b). *A chaos model of group process research.* Unpublished manuscript.

Wilbur, M.P., J. Kulikowich, J. Roberts-Wilbur, & E. Torres Rivera. (1995a). 'Chaos theory and counselor training'. *Counseling and Values, 39*:129-44.

Wilbur, M.P., J. Roberts-Wilbur, & R.L. Betz. (1981). 'Leader and member behaviors in three group modalities: A typology'. *Journal for Specialists in Group Work, 6*:224-34.

Wilbur, M. P., J. Roberts-Wilbur, E. Torres Rivera, & J. Kulikowich. (1995b). 'Future directions: Chaos theory and nonlinear counseling'. *Journal for the Professional Counselor, 10*:73-90.

Worchel, S. (1994). 'You can go home again: Returning group research to the group context with an eye on developmental issues'. *Small Group Research, 25*:205-23.

Yalom, I. D. (1995). *The theory and practice of group psychotherapy.* 4th ed. New York: Basic Books.