Observing Gay, Lesbian and Heterosexual Couples' Relationships: Mathematical Modeling of Conflict Interaction

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ABSTRACT. Two samples of committed gay and lesbian cohabiting couples and two samples of married couples (couples in which the woman presented the conflict issue to the man, and couples in which the

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man presented the conflict issue to the woman) engaged in three conversations: (1) an events of the day conversation (after being apart for at least 8 hours), (2) a conflict resolution conversation, and (3) a pleasant topic conversation. The observational data were coded with a system that categorized specific affects displayed. Data were weighted and two time-series created, one for the husband and one of the wife. The time series were modeled with nonlinear difference equations (Cook et al., 1995), and parameters were estimated that indexed uninfluenced steady state, influenced steady state, emotional inertia, repair effectiveness and threshold, and the power of positive and negative affect of one partner to affect the other partner.

KEYWORDS. Relationships, interaction, stability, dissolution, emotions, humor, affection, criticism, contempt, prediction

Although there is a venerable history of research on gays and lesbians as individuals, relatively little descriptive scientific research exists about gay and lesbian *relationships*. This is certainly not because gay and lesbian relationships are rare. Even in research done at the Kinsey Institute in the 1960s, Weinberg, and Williams (1974) reported that 71 percent of a sample of gay men between the ages of 36 and 45 were living with a partner. In the 1970s Bell and Weinberg (1978) found that 82% of their lesbian sample were currently living with someone. Gay men and lesbian women have always been very concerned about having satisfying and stable relationships, and since the AIDS epidemic this interest in the gay and lesbian communities in having stable committed relationships has increased (Andriote, 1999).

In the 1980s an important book, *American Couples* (Blumstein & Schwartz, 1983), reported the results of over 12,000 questionnaires and more than 300 interviews with gay, lesbian, married heterosexual, and cohabiting heterosexual couples on issues related to money, work, power, and sex. The timing of this landmark study, meant that it preceded the AIDS epidemic, which was to have such a large impact on gay and lesbian relationships. The Blumstein and Schwartz study provided one of the first opportunities to compare heterosexual and homosexual relationships.

Since 1983 sophisticated longitudinal research has been conducted on gay, lesbian and heterosexual married couples by Kurdek and his associates (e.g., Kurdek, 1998). Kurdek concluded that gay and lesbian relationships operate on essentially the same principles as heterosexual relationships, except that there are fewer barriers to leaving, and gay relationships emphasize autonomy more than do heterosexual relationships. He wrote, that by and large, the "correlates of relationship quality have been found to be very similar for gay and lesbian couples (Blumstein and Schwartz, 1983; Duffy and Rusbult, 1986; Kurdek and Schmitt, 1986)" (Kurdek, 1992, p. 130). There were some differences as well. Compared to married partners, gay partners reported more autonomy, fewer barriers to leaving and more frequent relationship dissolution. Compared to married partners lesbian relationships reported more intimacy, more autonomy, more equality and more frequent relationship dissolution. He wrote, "Overall, the strength with which the dimensions of relationship quality were linked to each relationship outcome for married partners was equivalent to that for both gay and lesbian partners" (Kurdek, 1998, p. 553).

Previous research on gay and lesbian relationships has provided important insights on the nature of these relationships; however, it has relied entirely on self-report data derived from questionnaires (e.g., Kurdek, 1992), or questionnaires and interviews (e.g., Blumstein & Schwartz, 1983). While these forms of data produce valuable information, they are limited to people's *perceptions* of their own relationships. There is considerable evidence that people's perception of their relationships may diverge quite markedly from their actual interaction. For example, in an observational study of positive interaction at home, Robinson and Price (1980) found that, compared to observers, distressed couples underestimated positive interaction by 50%. Hence, there may be valuable information to be gained by employing observational research to study gay and lesbian relationships.

This paper reports the results of what, to our knowledge, is the first observational study of gay and lesbian relationships. These observational data are used to support mathematical modeling of the nature of interaction in these relationships. The mathematical modeling provides both descriptive and theoretically-based data about interaction.

Two samples of heterosexual couples were also part of the experimental design of this study. Analyzing the interaction of gay, lesbian, and heterosexual couples presents a thorny issue in distinguishing between the two partners. With heterosexual couples, researchers usually distinguish "husbands" and "wives" but this cannot be done with same-sex couples. In our research we addressed this issue by taking advantage of the fact that our paradigm had couples discuss an area of conflict in their interaction. We distinguished between partners in our analyses by noting which partner initially presented the conflict. The samples of heterosexual couples were chosen so that in one group, the wife presented the issue to the husband and in the other the husband presented the issue to the wife. When all couples were combined, a 2×2 factorial design resulted in which the first factor indicated who initiated the issue (a man or a woman), and the second factor indicated whether the couple was homosexual or heterosexual. In this manner, we could compare the interaction when a man presented a relationship issue to a man he was committed to the interaction when a man presented a relationship issue to a woman he was committed to. Similarly, we could compare the interaction when a woman presented a relationship issue to a woman she was committed to with the interaction when a woman presented a relationship issue to a man she was committed to. This approach contrasts with Kurdek's, who randomly assigned each partner in the homosexual relationship either to be "Partner 1" or "Partner 2" and then analyzed the data twice. In our approach, one partner was designated "the initiator" of the issue and the other was designated "the partner."

Mathematical Modeling of Marital Interaction. Before presenting our methods and findings, we will provide some background on mathematical modeling intended to set the stage for what follows. For the past seven years our laboratory has been constructing mathematical models of marital interaction (Cook et al., 1995; Gottman et al., 1998). This modeling involves estimating two linked nonlinear difference equations, one for the husband and one for the wife (described next). The desire to create these mathematical models was inspired by *General System Theory (*Von Bertalanffy, 1963). This book inspired many major thinkers of family systems and family therapy, including Gregory Bateson, Don Jackson, and Paul Watzlawick. Unfortunately, the mathematics of General System Theory was not utilized by most of the social scientists who influenced by von Bertalanffy's work. Bateson and colleagues originally envisaged making their family systems theory mathematical (for an historical review see Gottman, 1979), but did not do so. Hence, the nonmathematical work of these theorists of family interaction kept their systems concepts at the level of metaphor. Even at the level of metaphor these concepts were tremendously influential in the field of family therapy (see Rosenblatt, 1994). However, they were never quantified or subjected to experimental processes.

Von Bertalanffy clearly viewed his theory as mathematical. He believed that the interaction of complex systems with many units could be characterized by a set of values that change over time, denoted Q_1, Q_2, Q_3, and so on. Each of these Q's were variables that indexed something about a particular unit in the system, such as mother, father, and child. He thought that the system could be best described by a set of ordinary differential equations of the form:

$$dQ_1/dt = f_1(Q_1, Q_2, Q_3, \ldots)$$
$$dQ_2/dt = f_2(Q_1, Q_2, Q_3, \ldots)$$

and so on.

The terms on the left of the equal sign are time derivatives, that is, rates of change of the quantitative sets of values Q_1, Q_2, and so on. The terms on the right of the equal sign are functions, f_1, f_2, . . . , of the Q's. Von Bertalanffy thought that these functions, the fs, might generally be nonlinear. The equations Von Bertalanffy selected have a particular form, called "autonomous," meaning that the fs have no explicit function of time in them, except through the Qs, which are functions of time. Von Bertalanffy had no suggestions for what the Qs ought to measure, nor what the fs ought to be. So his vision remained a creative one without a quantitative science to back it up.

We obtained the Qs for our modeling from our ability to predict the longitudinal course of marriages. Gottman and Levenson (1992) reported that a variable that describes specific interaction patterns in terms of the balance between negativity and positivity was predictive of marital dissolution. In this work, we used a methodology for obtaining synchronized physiological, behavioral, and self-report data in a sample of 73 couples who were followed longitudinally during a four-year period. Applying observational coding of interactive behavior with the Rapid Couples Interaction Scoring System (RCISS, Krokoff, Gottman & Hass, 1989), couples were divided into two groups, a low-risk group and a high-risk group. This classification was based on a graphical method originally proposed by Gottman (1979) for use with the Couples Interaction Scoring System, a predecessor of the RCISS. On each conversational turn the total number of positive RCISS speaker codes minus the total number of negative speaker codes was computed for each spouse. Then the cumulative total of these points was plotted for each spouse. The slopes of these plots, which were thought to provide a stable estimate of the difference between positive and negative codes over time, were determined using linear regression analysis. The decision to utilize the slopes in this way was guided by a balance theory of marriage, namely that those processes most important in predicting dissolution would involve a balance, or a regulation, of positive and negative interaction. Low-risk couples were those for whom both husband and wife speaker slopes were significantly positive; high-risk couples had at least one of the speaker slopes that was either negative or not significantly positive. We found that the high/low-risk distinction was able to predict the "cascade" toward divorce, which consisted of: (a) marital dissatisfaction, (b) persistent thoughts about divorce and separation, and (c) actual separation and divorce. The ability to predict the longitudinal course of marital relationships in this manner has now been found in our laboratories in four separate longitudinal studies (see Gottman, 1993, 1994; Gottman, Coan, Swanson, & Carrere, 1998; Jacobson et al., 1996).

In our first paper using mathematical modeling (Cook et al., 1995), we made use of these speaker slopes as the Qs in our equations and used them to develop a mathematical model that might explain the Gottman-Levenson findings. Our own equations were very similar to the ones that Von Bertalanffy had envisioned, except that we used discrete difference equations rather than differential equations. There is one additional difference. Von Bertalanffy thought that the equations had to be linear. He presented a table in which these nonlinear equations were classified as "Impossible" (von Bertalanffy, 1968, p. 20), referring to the very popular mathematical method of approximating nonlinear functions with a linear approximation. Unfortunately, linear equations are not generally stable, so they tend to give erroneous solutions, except as approximations under very local conditions near a steady state. Von Bertalanffy was not aware of the mathematics Poincarè and others had developed in the last quarter of the 19th century for the study of nonlinear systems. It was actually no longer the case that these nonlinear systems were "impossible," even in Von Bertalanffy's day. This is even more true today when the modeling of complex deterministic (and stochastic) systems with a set of nonlinear difference or differential equations has become a productive enterprise across a wide set of phenomena in a wide range of sciences. Thus, the use of nonlinear equations formed the basis of our first attempts at modeling marital interaction (these methods are described in detail in Cook et al., 1995).

This general method of mathematical modeling with nonlinear equations has been employed with great success in the biological sciences, and many departments of applied mathematics now have a mathematical biology program (Murray, 1989). It is a quantitative approach that allows the modeler to be able to write down, in mathematical form, on the basis of some theory, the causes of change in the dependent variables. For example, in mathematical ecology, in the classic predator-prey problem, one writes down the rate of change in the population densities of the prey and of the predator as some function of their current densities (e.g., Murray, 1989). While this is a simple representation of the predator-prey phenomenon, it has served well as an initial exploratory model. An advantage of nonlinear equations (in addition to their possibility of stability) is that by employing nonlinear terms in the equations of change some very complex processes can be represented with very few parameters. Unfortunately, unlike many linear equations, these nonlinear equations are generally not solvable in closed functional mathematical form. For this reason the methods are often called "qualitative," and visual graphical methods and numerical approximation must be relied upon. For this purpose, numerical and graphical methods have been developed such as "phase space plots." These visual approaches to mathematical modeling can be very appealing in engaging the intuition of a scientist working in a field that has no mathematically stated theory. If the scientist has an intuitive familiarity with the data of the field, our approach may suggest a way of building theory using mathematics in an initially qualitative manner. The use of these graphical solutions to nonlinear differential equations makes it possible to talk about "qualitative" mathematical modeling. In qualitative mathematical modeling, one searches for solutions that have similarly shaped phase space plots, which provide a good qualitative description of the solution and how it varies with the parameters.

Another advantage of this kind of modeling is that it permits the *simulation* of the couple's interaction under new conditions, with different parameter values, such as when a partner begins the interaction much more positively than has ever been observed. This possibility leads to natural experiments. There are many excellent introductions to this general approach to qualitative nonlinear dynamic modeling and its subtopics of chaos and catastrophe theory. We refer the reader to a few sources here. A general introduction to chaos theory was provided in a popular book by Gleick (1987), and a clear introduction to its mathematics by the physicists Baker and Gollub (1996). Qualitative modeling is introduced by Morrison (1991). Introductions to the mathematics of this approach (a system of nonlinear differential equations) can be found in Brauer and Nohel (1969), and Jordan and Smith (1987). Introductions to the extension from differential to difference equations can be found in Goldberg (1986) and in Kelley and Peterson (1991). Applications to the study of disease can be found in Glass and Mackey (1988), to biological rhythms by Winfree (1990), to weather by Lorenz (1993), to the study of turbulence by Berge, Pomeau, and Vidal (1984), to the study of capital markets by Peters (1991), to social and biological sciences by Beltrami (1993), and to social psychology by Vallacher and Nowack (1994). An introduction to catastrophe theory may be found in Arnold (1986), Castrigiano and Hayes (1993), Gilmore (1981), and Saunders (1990). The currently vast and expanding area of mathematical biology is introduced by Murray (1989).

Our modeling of marital interaction using the mathematical methods of nonlinear difference equations is an attempt to integrate the mathematical insights of von Bertalanffy with the General Systems Theorists of Family Systems (Bateson, Jackson, Haley, & Weakland, 1956) using nonlinear equations. A basic concept in this modeling is that every system of equations has one or more stable or unstable "steady states" or "attractors." These stable attractors are like the old family systems notion of homeostatic set points of the system. These are values toward which the system is drawn, and, if perturbed from the stable attractor, returns the system back toward it. In our modeling there were both uninfluenced attractors and influenced attractors.

The Concept of Repair. In theorizing about mother-infant interaction, Brazelton (e.g., Brazelton, Koslowski, & Main, 1974) had suggested that "repair" was the *sine qua non* of human interaction, and that the healthy norm was a cyclic shared rhythmicity and coordination of interaction. However, Gianino and Tronick (1988), in observing mother-infant interaction, reported that 70% of mother-infant interaction was actually miscoordinated. What they found was that some mothers noticed the miscoordination and tried to *repair* the interaction, while other mothers did not. The mother's use of repair later predicted the infant's attachment security. Gianino and Tronick built a theory of interactive regulation and repair based on their findings. In our own modeling we studied couple's *repair* of negativity, which, in our research on married couples is the one central theoretical construct that has consistently discriminated those couples whose marriages were dissatisfied and headed for divorce from those whose marriages were satisfied and stable (e.g., see Gottman, 1999).

Parameters of the Modeling. Our initial modeling (Cook et al., 1995) produced the following parameters. First, there was the *uninfluenced steady state* for each partner, which represented the attractors reflecting what that partner brought into the interaction before influence began. This uninfluenced state turned out to be a function both of that partner's personality and the immediate past history of the relationship (Gottman et al., 1998). Second were the *inertia* parameters, which assessed the tendency of each person's behavior to be predictable from that person's immediate past behavior. Third, were the *influenced steady states*, which were where each partner was drawn to following the social influence process. Fourth, were the influence functions, which, for each affect value, describe the average effect of that affect (over the entire interaction) on the partner. These influence functions provide a more detailed description of interpersonal influence or power. Power has been an elusive construct in the study of relationships (for a critique and review see Gray-Little and Burks, 1983). Power is defined in our modeling as the ability of one person's affect to move the other partner's affect.

Fifth, our initial model has now been modified to include a *Repair* term, which is repair of negative interaction that is potentially triggered at a particular threshold of a partner's negativity and is effective at pushing the data in a more positive direction. The two Repair terms have two parameters, the threshold of the repair and its effectiveness.

METHOD

Participants

Gay and Lesbian Samples. Couples were recruited by placing advertisements in the classified sections of Berkeley and San Francisco gay newspapers, posting flyers, contacting various gay and lesbian groups, and making public service announcements on Bay area radio stations. Advertisements and announcements asked for "volunteer couples, including those with relationship problems, needed for a paid UC Berkeley research project on committed relationships." Partners had to be between the ages of 21 and 40 and living together in a committed relationship for at least two years. Respondents were paid $10.00 for completing a General Information Form and a modified version of the Locke-Wallace (Locke & Wallace, 1959). Based on these data, 40 couples were invited to participate in the second phase of the study. To insure a reasonable sampling of levels of relationship satisfaction, we established a score of 115 or higher for the partner's averaged Locke-Wallace scores as indicating a "happy" couple and below 115 as indicating an "unhappy" couple (the final sample consisted of 12 gay happy couples, 10 gay unhappy couples, 10 lesbian happy couples, and 8 lesbian unhappy couples. Other inclusion criteria were: (1) no more than a

10 year difference in ages between partners, (2) childless, (3) no previous committed (i.e., living together) heterosexual relationships, (4) discrepancy between partners in modified Locke-Wallace relationship scores of no more than 25 points, and (5) couple speaks English to one another at home.

The second phase of the study consisted of filling out a larger battery of questionnaires and coming to the Berkeley campus for three research sessions in the laboratory. Both partners attended the first session together and each partner attended one additional session separately. Each session lasted for two to three hours. Couples participating in this second phase were paid $40.00 for completing the laboratory sessions.

Married Couple Sample. The comparison sample of married couples was selected from a larger longitudinal study that recruited couples from the environs of Bloomington, Indiana, beginning in 1983. Married couples from this sample were matched in relationship satisfaction and length of their relationship to the gay and lesbian samples. All couples had participated in a marital interaction paradigm that included a discussion of a conflict area in the relationship (see below for details of this procedure). Twenty married couples were selected where the husband had presented the conflict issue, and 20 couples were selected where the wife had presented the conflict issue. The disparity in geographical location between the married couple sample and the gay and lesbian samples was also characteristic of Kurdek's longitudinal study; in that study the gay and lesbian samples were recruited nationally and the married couple sample resided in Dayton, Ohio. Kurdek had the problem of how to describe or assign same-sex partners to some condition such as the roles of husband and wife. He randomly assigned same-sex partners to "Partner 1" or "Partner 2," and then re-analyzed his data two ways. For our analysis we employed a psychological criterion to distinguish among partners in all relationships. The partner who initiated and presented the major core relationship issue was called the "Initiator," and the other was called the "Partner." This determination could be made independently by two observers with high reliability (100%). This created a 2×2 factorial design, with one factor being sexual preference (Homosexual/Heterosexual), and the other the sex of the initiator as either male or female. We selected married couples from a longitudinal study that had used procedures identical to those of the gay-lesbian study. From the set of 79 couples we selected 20 in which the husband presented the marital issue to his wife and 20 in which the wife presented the marital issue to the husband; these 40 couples were selected so that they matched the gay-lesbian couples in age, relationship satisfaction, and education and income. This selection produced the following 2×2 factorial experimental design:

	Homosexual	**Heterosexual**
Male Initiates	Gay Male	Married, husband initiates
Female Initiates	Lesbian	Married, wife initiates

The experimental design specifies two dimensions. The first dimension is *who initiated* the discussion of the relationship issue, a male or a female. The second dimension is *sexual orientation*, whether the relationship is homosexual or heterosexual. This design makes it possible to assess gender main effects (all males compared to all females) separate from relationship-specific effects. Designs that do not include gay and lesbian relationships confound gender with possible dominance effects.

Demographics. The lesbians were an average of 29.3 years old, and the gay men were an average of 32.5 years old. The married couples for which the women initiated the conflict discussion were an average of 28.7 years old, and the married couples for which the men initiated the conflict discussion were an average of 29.6 years old. The mean Locke-Wallace relationship satisfaction scores of the lesbians was 113.2, and the mean Locke-Wallace relationship satisfaction scores of the gay men was 116.0. The mean Locke-Wallace relationship satisfaction scores of the married couples for which the women initiated was 121.8, and mean Locke-Wallace relationship satisfaction scores of the married couples for which the men initiated was 99.0.

Interaction Session. The procedures employed in this study were modeled after those developed by Levenson and Gottman (1983) and were used for both the heterosexual and homosexual couples. Couples came to the laboratory after having not spoken to each other for at least eight hours. After recording devices for obtaining physiological measures were attached, couples engaged in three conversations: (a) discussing the events of the day; (b) discussing an area of continuing conflict and disagreement in their relationship; and (c) discussing a mutually agreed upon pleasant topic. Each conversation lasted for 15 minutes and was preceded by a five-minute silent period. During the silent periods and conversations, a broad sample of physiological measures was obtained and a video recording was made of the interaction.

For the events of the day conversion, subjects were simply told to discuss what had happened during the day. Prior to initiating the conflict area discussion, couples completed the Couple's Problem Inventory (Gottman, Markman & Notarius, 1977), in which they rated the perceived severity of 10 relationship issues on a 0-to-100 scale. During the conflict discussion partners were designated either "initiators" if they were the one presenting the issue, or "partner" if they were the recipient of the issue. Prior to initiating the pleasant topic discussion, couples completed a similar inventory, in which they rated the enjoyment they derived from 16 topics on a 0-to-100 scale. The experimenter used these inventories to help couples select the topics that were used in these two conversations.

For purposes of the present study, only data from the conflict area discussion were utilized.

Observational Coding. The Specific Affect Coding System (SPAFF; Gottman, McCoy, and Coan, 1996) was used to code the events of the day and conflict area conversations of all couples. SPAFF focuses solely on the specific affects expressed. The system draws on facial expression (based on Ekman and Friesen's system of facial action coding; Ekman & Friesen, 1978), vocal tone, and speech content to characterize the emotions displayed. Coders categorized the affects displayed using five positive affect codes (interest, validation, affection, humor, excitement/joy), 10 negative affect codes (disgust, contempt, belligerence, domineering, anger, fear/tension, defensiveness, whining, sadness, stonewalling), and a neutral affect code. The dependent variables created were the total number of seconds duration of each SPAFF code out of the 900 seconds of the conflict area discussion. Every videotape was coded in its entirety by two independent observers using a computer-assisted coding system that automated the collection of timing information; each coder noted only the onset of each code.

A time-locked confusion matrix for the entire videotape then was computed using a 1-second overlap window for determining agreement of each code in one observer's coding against all of the other observer's coding (see Bakeman & Gottman, 1986). For the conflict segment, for married couples the Cronbach alpha generalizability coefficients summed over partners were: affection, .88; anger, .76; belligerence, .89; contempt, .92; defensiveness, .99; disgust, .62; domineering, .96; humor, .95; interest, .92; excitement/joy, .32; sadness, .82; stonewalling, .64; fear/tension, .98; validation, .97; and whining, .86. For gays and lesbians, for the conflict segment, the Cronbach alpha generalizability coefficients summed over partners were: affection, .86; anger, .86; belligerence, .91; contempt, .67; defensiveness, .97; disgust (a low frequency code), .37; domineering, .84; humor, .96; interest, .75; excitement/joy, .56; sadness, .72; stonewalling, .75; fear/tension, .95; validation, .96; and whining, .81.

Weighting of the SPAFF Codes. For the mathematical modeling we used a weighting scheme derived from previous prediction research (Gottman, 1994). A numerical value was calculated for the SPAFF codes for each 6-second time block separately for each partner by taking the sum of positive codes minus the negative codes using the following weights: Disgust = −3, Contempt = −4, Belligerence = −2, Domineering = −1, Anger = −1, Fear = 0, Defensiveness = −2, Whining = −1, Sadness = −1, Stonewalling = −2, Neutral = 0.1, Interest = +2, Validation = +4, Affection = +4, Humor = +4, and Excitement/Joy = +4. This weighting yields a potential score range of −24 to +24. For each couple this created two time series, each with 150 data points, one series for the "initiator" and one for the "partner." For married couples, combined across partners, the correlation for the two observers of total weighted SPAFF over the conflict interaction was .90 ($p < .001$). For the gays and lesbians, combined across partners, the correlation for the two observers of total weighted SPAFF over the conflict interaction was .52 ($p < .01$).

Mathematical Modeling. A mathematical model using nonlinear difference equations was fit to the weighted SPAFF data during the conflict discussion for all couples. This model has been developed and tested with a number of samples of married couples (Cook et al., 1995; Gottman, Swanson, & Murray, 1999; Gottman, Murray, Swanson, Tyson, & Swanson, in press). For this study there were two time-series, the initiator's and the partner's. The initiator's time series was denoted N_t, and the partner's time series was denoted P_t, where t is time. These equations model both initiator and partner time series as follows:

$$N_{t+1} = r_1 N_t + a + I_{P\text{-}>N}(P_t) + E_{PR} R(K_P) + E_{PD} D(K_P), \text{ and}$$
$$P_{t+1} = r_2 P_t + b + I_{N\text{-}>P}(N_t) + E_{NR} R(K_N) + E_{ND} D(K_N)$$

The parameters in these equations are defined in the following way. The r's are emotional inertia parameters that assess lag-one autocorrelation in each series: r_1 assesses the lag-one autocorrelation for series N_t and r_2 assesses the lag-one autocorrelation for series P_t. The a and b parameters assess the initial uninfluenced states of the initiator and partner. Thus, the $(r_1 N_t + a)$ term in the first equation and the $(r_2 P_t + b)$ term in the second equation are the full autocorrelation terms. For those points when only the autocorrelation functions (and there is no influence, repair or damping), the uninfluenced steady states (neither N nor P are changing) are computed from the equations:

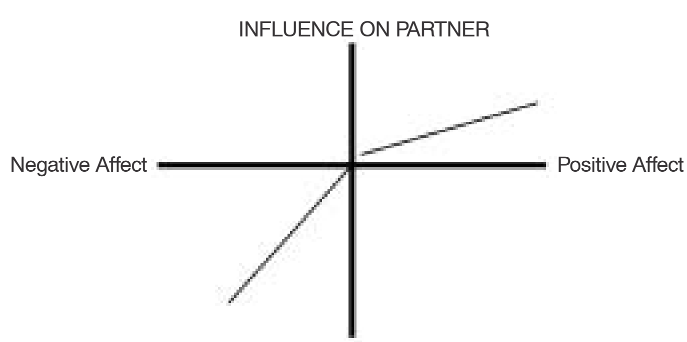
$$N = r_1 N + a, \text{ or } N = a/(1 - r_1), \text{ and}$$
$$P = r_2 P + b, \text{ or } P = b/(1 - r_2)$$

They are estimated using a least-squares fit.

The Is are the influence functions, with $I_{P->N}(P_t)$ denoting the influence of the partner on the initiator, as a function of the partner's behavior, and $I_{N->P}(N_t)$ denoting the influence of the initiator on the partner, as a function of the initiator's behavior. The influence functions in each equation are the cross-correlation terms. They specify the average amount of influence each partner has on the other at a particular level of weighted positive-minus-negative affect (over time). The functional form of the influence function we have found to fit our data the best is the bilinear form (Figure 1). In the bilinear function there are two slopes, the influence of positive and negative affect ranges on the partner. There are, of course, two influence functions. Differences in slopes are our operational definition of *power* in the relationship, which is defined separately for positive and negative affect.

In nonlinear dynamic mathematical modeling (e.g., see Murray, 1989) these influence functions determine what are called the "null clines" of the equations, which are the curves in the N-by-P phase space where the initiator is steady and the partner is steady. Where the null clines intersect determine the influenced "steady states" of the system of equations. Steady states can be stable or unstable. If the steady states

FIGURE 1. Bilinear Influence Function



are stable, the influenced steady states are also called the "attractors" of the dyadic system. They may be compared to gravitational attractors. As noted previously, the system is drawn to these states, and, if perturbed slightly away from an attractor, the system is pulled back to the attractor. There can be more than one attractor for a dyadic system. Often there are both negative and positive attractors for each couple. These attractors determine how the system moves in the long run.

We recently modified this mathematical model so that it became possible to estimate repair terms that represents a couple's attempts to improve their communication when it becomes sufficiently negative. We also defined analogous "damping" terms that represent a couple's attempts to modulate the positivity of their influence on one another when the interaction becomes sufficiently positive, but we do not yet fully understand the theoretical meaning of damping. We viewed repair as a communication strength and damping as a communication deficit. Adding these terms to the model improved the fit of the model by an order of magnitude. The E_{PR} $R(K_P)$ term in the first equation and the E_{NR} $R(K_N)$ term in the second equation represent the effectiveness of repair and the threshold trigger of negativity at which repair is activated. The R(.) function is a standard trigger function that makes the time series jump to a higher value with amplitude E (the effectiveness of repair) at the trigger threshold of negativity, K. The E_{PD} $D(K_P)$ term in the first equation and the E_{ND} $D(K_N)$ in the second equation represent the effectiveness and thresholds of damping functions that act as a mirror of repair, reducing the positive effects of positive affect after K, a threshold trigger of positivity is crossed with effectiveness E. Details of the algorithms for estimating each model parameter and the influence functions are available in Gottman, Murray, Swanson, Tyson, and Swanson (in press).

RESULTS

Uninfluenced Steady States. For the uninfluenced steady state of the *initiator* of the issue, there was a significant effect only for sexual orientation, $F(1,75) = 8.18$, $p = .005$. The homosexual mean was 0.61, and the heterosexual was $-.98$. There was no significant difference between gay and lesbian relationships, $t(77) = 1.09$, ns, nor between heterosexual couples in which the man or woman initiated, $t(77) = .45$. For the uninfluenced steady state of the *partner*, there was again only a significant effect for sexual orientation, $F(1,75) = 6.45$, $p = .013$. The homosexual mean was 0.37, and the heterosexual mean was −1.09. There was again no significant difference between gay and lesbian relationships, t(77) = 1.37, ns, nor between heterosexual couples in which the man or woman initiated, t(77) = .89. Thus, this means that the way the issue is presented and received in the conflict interaction is positive for homosexual couples and negative for heterosexual couples. These results suggest that, by analyzing observational data, homosexual relationships may be fundamentally different from heterosexual relationships.

Subsequent Analyses of Specific SPAFF Codes. These analyses showed that homosexual *initiators* of the conflict issue compared to heterosexual initiators were characterized by less negative affect: less belligerence, t(76) = 2.72, p < .01 (homosexual mean = 2.65, heterosexual mean = 10.57); less domineering, t(76) = 2.38, p < .05 (homosexual mean = 7.56, heterosexual mean = 33.18); less fear/tension, t(76) = 4.02, p < .001 (homosexual mean = 21.52, heterosexual mean = 121.76); less sadness, (t(76) = 3.89, p < .05 (homosexual mean = 6.87, heterosexual mean = 30.21); less whining, t(76) = 1.97, p < .05 (homosexual mean = 2.30, heterosexual mean = 10.29). The homosexual initiators of the conflict also demonstrated more positive emotions when compared with the heterosexual initiators: more affection, t(76) = 1.75, p < .05 (homosexual mean = 1.82, heterosexual mean = .89); more humor, t(76) = 3.91, p < .001 (homosexual mean = 29.61, heterosexual mean = 9.45); and more joy/excitement, t(76) = 2.34, p < .05 (homosexual mean = .46, heterosexual mean = .007). For the *partner* (i.e., the recipient of the conflict issue), homosexual compared to heterosexual partners showed less negative affect: less belligerence, t(76) = 2.28, p < .05 (homosexual mean = 1.61, heterosexual mean = 5.96); less domineering, t(76) = 2.52, p < .05 (homosexual mean = 9.06, heterosexual mean = 38.88); less fear/tension, t(76) = 7.60, p < .001 (homosexual mean = 15.48, heterosexual mean = 94.71). The homosexual *partners* also showed significantly more humor than the heterosexual partners, t(76) = 3.86, p < .001 (homosexual mean = 29.71, heterosexual mean = 9.38). These results suggest that homosexual relationships may be distinguished from heterosexual relationships in the expression of specific positive and negative affects during a conflict interaction.

Influenced Steady States. For the influenced steady states, we computed the number of stable steady states in each of the four quadrants of phase space. The only significant difference was in the quadrant where both of their behavior is positive, and again there was a sexual orientation effect, F(1,75) = 5.25, p = .025. The mean number of influenced stable steady states in this quadrant for the homosexual couples was .86 versus .32 for the heterosexual couples. There was also a marginally significant interaction between sexual orientation and the gender of the initiator, $F(1,75) = 3.89$, $p = .052$. Subsequent tests showed that the *lesbian* mean of 1.14 stable steady states in the positive-positive quadrant was significantly higher than the other three types of couples (gay male mean = .57, man initiating to a woman = .50, woman initiating to a man = .19). Once again, these results suggest that influence processes in homosexual committed relationships may be dissimilar to the influence processes found in heterosexual couples. These findings imply that lesbian couples, when compared with the gay and heterosexual couples, are more likely to remain stable in their behavioral interactions when both partners are positive in their communication content.

Repair Effectiveness. There were no significant main effects due to sexual orientation or to who *initiates* the issue, for either the initiator's or the partner's repair effectiveness. However, subsequent t-tests revealed some interesting findings on *partner's* repair effectiveness. The mean was lower for gay male couples than in any of the other 3 groups (gay mean = 2.78, man initiated to a woman mean = 3.98, woman initiated to a man mean = 3.99, lesbian mean = 3.65). There was a significant difference between homosexual and heterosexual couples where the man initiates, $t(69) = 1.70$, $p < .05$. There was also a significant difference between a woman initiating to a man (the most common occurrence in heterosexual couples) and a man initiating to a man in a gay couple, $t(69) = 1.80$, $p < .05$. These results suggest the following interpretation of the data: when a gay man presents the conflict issue to his partner and the initiator becomes too negative, his partner may not repair very effectively. This finding suggests that interventions for gay male couples in particular may do well focusing on the repair aspects of conflict regulation.

Repair Threshold. There were no significant effects for the *initiator's* negative score threshold that triggers repair by their partner. However, there was a significant effect for the *partner's* threshold that triggered repair, and in this case the effect was due to who brought up the issue to be discussed, $F(1,69) = 5.14$, $p = .027$. Recall that the threshold for negativity is how negative the initiator's behavior needs to get for the partner to start trying to repair. The mean threshold of negativity when a man initiated the issue was -4.64, compared to a mean of -6.04 when a woman initiated the issue. This means that when a man initiates the issue, he detects negativity in his partner and attempts to repair *sooner* (that is, before it gets too negative) compared to a woman when she is presenting the issue. In addition, there was a marginally significant interaction effect, $F(1,69) = 3.03$, $p = .086$. A subsequent t-test showed that this was due to the fact that when a *heterosexual* man initiates the issue, he notices and responds to negativity in his partner at a much less negative threshold than in any other group, $t(69) = 2.48$, $p < .01$.

Damping Effectiveness. There was a significant effect for the *initiator's* effectiveness of damping, and the effect was due to sexual orientation, $F(1,73) = 4.98$, $p = .029$. The mean initiator's effectiveness of damping for homosexual couples was -4.85, as compared to -3.11 for heterosexual couples. It is the magnitude and not the sign of this measure that is important (it is expected to be a negative number precisely in order to have a damping effect on the underlying influence function). In addition, there was a marginally significant effect for the *partner's* effectiveness of damping, and the effect was also due to sexual orientation, $F(1,70) = 3.91$, $p = .052$. The mean partner's effectiveness of damping for homosexual couples was -5.03, as compared to -3.37 for heterosexual couples. Thus, when either partner in the homosexual couples detected that the other person had become "too positive" (perhaps treating a serious issue with too much levity), they were more effective at damping this down than were the heterosexual couples. Damping is a decrease in positive influence; it is not a dysfunctional part of the model because we have discovered that damping may create a positive-positive stable steady state ("attractor") where none existed before.

Affect and Influence Patterns. In every study we have conducted with *heterosexual* couples using the mathematical modeling, the slope of the influence functions in the negative affect range is steeper than the slope in the positive affect range. Gottman (1994) referred to this as "the triumph of negative over positive affect," meaning that it is easier to hurt one's partner with negative affect than it is to have a positive influence with positive affect. In the present study when we compared homosexual relationships with heterosexual relationships we found some indication that for homosexuals there was a reversal of the pattern. The variable used in this analysis was the slope for positive affect minus slope for negative affect, so a negative value indicates the negative affect slope is steeper (i.e., the usual finding). For the *initiator's* influence function there was a marginal interaction effect, $F(1,66) = 3.05$, $p = .085$ (man initiates to woman mean = $-.086$, woman initiates to man mean = $-.283$, gay male mean = $-.331$, lesbian mean = $-.122$). The means suggested a difference between the heterosexual men initiating to their wives and all other groups, but a subsequent t-test did not find this to be significant. However, for the *partner's* influence function there was a marginally significant effect for sexual orientation, $F(1,68) = 2.83$, $p = .097$ (heterosexual mean = −.19, homosexual mean = −.002). Hence, with increased power we may find a lessening of the effect of the triumph of negative over positive affect in homosexual couples.

Gender Effects. In addition to the gender threshold effect for the repair trigger previously noted, several other significant main effects for gender were found. Regardless of sexual orientation, men were more angry then women when presenting an issue, $t(77) = 1.75$, $p < .05$ (female mean = 1.55, male mean = 3.99) and women were more excited/joyful than men, $t(77) = 2.86$, $p < .003$ (female mean = .49, male mean = .004). For the partner, regardless of sexual orientation, women were more sad when receiving a conflict issue than men, $F(1,76) = 6.03$, $p = .016$ (female partner mean = 16.64, male partner = 2.06).

Differences Between Gays and Lesbians. There was inadequate power for the math modeling comparisons. However, there was enough power to find significant differences in affect. The SPAFF coding revealed, for the initiator of the issue, lesbians were more angry than gays, $t(76) = 1.66$, $p < .05$ (gay mean = 4.97, lesbian mean = 15.10), used more humor, $t(76) = 2.15$, $p < .05$ (gay mean = 21.88, lesbian mean = 37.33), and showed more excitement/joy, $t(76) = 3.55$, $p < .01$ (gay mean = .007, lesbian mean = .86). For the partner, lesbians showed more humor, $t(76) = 1.76$, $p < .05$ (gay mean = 23.29, lesbian mean = 36.14), and lesbians showed more interest, $t(76) = 1.95$, $p < .05$ (gay mean = to 1.24, lesbian mean = 6.00). These results suggest that lesbians are more emotionally expressive than gay men.

DISCUSSION

Because the mathematical modeling is unfamiliar to many readers, we would like to take the reader through a nontechnical discussion of the meaning of our findings. First, the model is able to decompose the observational data into *uninfluenced* and *influenced* components. Power, or influence, was defined in our modeling as the ability of one person's affect to move the other partner's affect. These two components may be thought of as (1) what each person brings into the interaction at its start, and (2) how each partner influences that start value as they talk. Using this particular experimental design (orientation by initiator), we were able to determine, from an examination of the uninfluenced steady states that in homosexual relationships the initiator of the conflict started positively, while in heterosexual relationships the initiator started negatively. Other research suggests that women presenting conflict issues to men is the most common pattern in heterosexual couples (Ball, Cowan, & Cowan, 1995; Oggins, Veroff, & Leber, 1993). This gender pattern fits with the well-known female demand-male withdraw pattern identified by Christensen and colleagues (e.g., Christensen and Heavey, 1990). However, in our design we were able to include male as well as female heterosexual initiators.

This homosexual/heterosexual pattern was echoed by the way the partner received the issue. Again, the homosexual *uninfluenced* partner affect mean was positive, while the heterosexual mean was negative. Thus, this means that the way the issue is presented and received in the conflict interaction is positive for homosexual couples and negative for heterosexual couples. These results suggest that, by analyzing observational data, homosexual relationships may be fundamentally different from heterosexual relationships.

This issue of "startup" is a critical issue in the management of conflict. It has made it possible for our laboratory to be able to predict divorce in married couples from just the first three minutes of a conflict discussion (Carrère et al., 2000).

A subsequent analysis of what specific affects contribute to this effect show that homosexual initiators were less belligerent and less domineering than heterosexual initiators. These findings are important in light of the heightened sensitivity to equity in homosexual compared to heterosexual relationships (Kurdek, 1998). For the *partner* (i.e., the recipient of the conflict issue), homosexual compared to heterosexual partners also showed less belligerence, less domineering, and less fear/tension. Clearly the results suggest that not only is equity a greater concern in homosexual relationships, but they behave in accordance with these concerns in the way conflict is initiated. Consistent with these results are the findings that there is less fear/tension, less sadness, less whining in homosexual initiators that heterosexual initiators.

But the effects are not only the inhibition of negative affects in startup of a conflict discussion. The data show that the homosexual initiators of the conflict also demonstrated more *positive* emotions when compared with the heterosexual initiators: more affection, more humor, and more joy/excitement. The homosexual *partners* also showed significantly more humor than the heterosexual partners.

Now let us consider the results about the influence process itself. For the influenced steady states, we computed the number of stable steady states in each of the four quadrants of phase space. These are called the "attractors" of the interaction. The presence of an attractor means that the interaction will tend toward that state, much as is the case for gravitational attraction. We found that the only significant difference in the attractors was in the quadrant where both partner's behavior is positive, and again there was a sexual orientation effect. The mean number of positive-positive attractors for the homosexual couples suggested that they tended to have an attractor in this quadrant, whereas this was far less likely for the heterosexual couples (the means were .86 versus .32, respectively). This was especially true for lesbians. Once again, using this experimental design, these results suggest that influence processes in homosexual committed relationships may be dissimilar to the influence processes found in heterosexual couples.

The results on *repair* were: for the *partner's* repair effectiveness, gay couples were less effective than all the other dyads in the study. These results suggested that when a gay man presents the conflict issue to his partner and the initiator becomes too negative, his partner may not repair very effectively. This finding suggests that interventions for gay male couples in particular may do well focusing on the repair aspects of conflict regulation.

The other part of repair is the *threshold* at which repair attempts begin. Recall that the threshold for negativity is how negative the initiator's behavior needs to get for the partner to start trying to repair. We found that when a man initiates the issue, he detects negativity in his partner and attempts to repair *sooner* (that is, before it gets too negative) compared to a woman when she is presenting the issue; this is true regardless of sexual orientation. It is particularly true that when a *heterosexual* man initiates the issue, he notices and responds to negativity in his partner at a much less negative threshold than any other group.

Damping is the converse of repair. It involves damping down the influence of one's partner's positive, rather than negative affect. Damping is a decrease in positive influence; it is not a dysfunctional part of the model because we have discovered that damping may create a positive-positive stable steady state ("attractor") where none existed before. As far as the initiator's damping was concerned, homosexual couples were more effective than heterosexual couples. In addition, there was a marginally significant effect for the *partner's* effectiveness of damping, and the effect was also due to sexual orientation. Thus, when either partner in the homosexual couples detected that the other person had become "too positive" (perhaps treating a serious issue with too much levity), they were more effective at damping this down than were the heterosexual couples.

Perhaps most exciting in the results is a suggestive rather than a definitive result. As we noted, in every study we have conducted with *heterosexual* couples using the mathematical modeling, the slope of the influence functions in the negative affect range is steeper than the slope in the positive affect range. We call this "the triumph of negative over positive affect" (Gottman, 1994), meaning that it is easier to hurt one's partner with negative affect than it is to have a positive influence with positive affect. In the present study when we compared homosexual relationships with heterosexual relationships we found some indication that for homosexuals there was a reversal of the pattern. The variable used in this analysis was the slope for positive affect minus slope for negative affect, so a negative value indicates the negative affect slope is steeper (i.e., the usual finding). For the *partner's* influence function there was a marginally significant effect for sexual orientation, and we speculate that with increased power we may find a lessening of the effect of the triumph of negative over positive affect in homosexual couples.

The current design is ideal for examining gender effects, independent of sexual orientation. In addition to the gender threshold effect for the repair trigger previously noted, we found only that regardless of sexual orientation, men were more angry then women when presenting an issue, while women were more excited/joyful than men. Also, for the partner, regardless of sexual orientation, women were more sad when receiving a conflict issue than men.

We had very little power to effectively study differences between gays and lesbians. The SPAFF coding revealed, that, for the initiator of the issue, lesbians were more angry than gays, used more humor, and showed more excitement/joy. For the partner, lesbians showed more humor, and lesbians showed more interest than gays. These results suggest that lesbians are more emotionally expressive, of both negative and positive affect than gay men.

Previous questionnaire and interview studies have suggested that committed gay and lesbian relationships are not fundamentally different than committed married heterosexual relationships in terms of such factors as the relationship between costs/benefits and relationship satisfaction and the determinants of the progress toward commitment. In fact, in a previous paper on the correlates of relationship satisfaction and stability in gay and lesbian relationships we also concluded that the correlates of relationship satisfaction do seem to be quite similar in heterosexual and homosexual committed relationships.

However, to summarize our findings, when we employed a 2 × 2 factorial study to compare the means of observed interaction between homosexual and heterosexual groups, accounting for who initiates the conflict issue, a different picture emerged. The mathematical modeling revealed interesting differences between heterosexual and homosexual couples in interactional dynamics when couples discussed areas of conflict in their relationships. In analyses of the *uninfluenced* steady states, we found that homosexual couples began far more positively and far less negatively in the way they presented an issue than heterosexual couples. Homosexual couples were also more positive in the way they received an issue from their partner than were heterosexual couples. Then, *after the social influence process* proceeded, homosexual couples were more likely to maintain a positive influenced steady state than were heterosexual couples. Finally, homosexual couples were more likely to have influenced states in the positive-positive quadrant of phase space than heterosexual relationships.

Furthermore, our results suggest that gay and lesbian relationships may operate on different principles than heterosexual relationships with respect to power and affect. Although there was inadequate power to test these results, the *pattern* of results suggest that homosexual couples were more positive in their influence on the partner in the positive affect ranges and less negative in their influence on the partner in the negative affect ranges than were heterosexual couples.

This observational approach to studying gay and lesbian relationships is important in its own right to determine the correlates (and eventually, the causes) of being able to maintain satisfying long-term committed homosexual relationships. Other research has shown that the *uninfluenced* steady state in and of itself is a significant predictor of divorce in heterosexual married couples (Cook et al., 1995; Gottman et al., 1998). Thus, based on our results, heterosexual relationships may have a great deal to learn from homosexual relationships insofar as homosexual relationships seem to have found a way to begin conflict discussions in a more positive and less negative manner, and to continue to have a positive rather than a negative influence on one another. Additional observational research is clearly called for to study the correlates of successful gay and lesbian relationships and parameters of interaction that are indicative of long-term stability and happiness in these relationships.

Why would gay and lesbian committed relationships differ so much from heterosexual couples both in the way they present and receive an area of continuing disagreement and in their influence patterns? And why would they differ by being so much more positive and less negative than heterosexual couples? We can only speculate about potential differences. We suspect that it has to do with two facts: (1) homosexual couples value equality far more than heterosexual couples, and (2) that there are fewer barriers to leaving homosexual than heterosexual relationships. The greater negativity and lowered positivity of heterosexual couples may have to do with the standard status hierarchy between men and women, a pattern that research has shown is largely absent in same-sex couples. It is well known that the status hierarchy in heterosexual relationships breeds hostility, particularly from women, who tend to have less power than men, and who also typically bring up most of the relationship issues. Because there are fewer barriers to leaving homosexual compared to heterosexual relationships, homosexual couples may be more careful in the way they accept influence from one another. Thus, we suggest that the process variables by which they resolve conflicts may be the very glue that keeps these relationships stable. Potentially, the reverse dynamic of the triumph of positive over negative affect that may characterize homosexual versus heterosexual relationships is a very exciting prospect.

Our findings on the lowered effectiveness of repair when the interaction does become negative is interesting, particularly for gay men. It suggests that interventions designed to help keep gay male relationships stable be focused on processes that may operate to harm repair processes. The most probable such process is physiological reactivity, which our research with marriages has shown is more of an issue for men than it is for women (Gottman & Levenson, 1988).

Subsequent research needs to expand the sample size of this investigation and to move beyond correlational data to experiments that attempt to improve relationships. These experiments are currently in the planning stages in our laboratories.

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