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Combining Dynamic Systems and Multivariate Analyses to Compare the Mother–Child Interactions of Externalizing Subtypes

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A dynamic systems analysis was conducted to distinguish the parent–child interactions of "pure" externalizing children from children comorbid for externalizing and internalizing problems. Thirty-three parents and clinically referred children (8–12 years old) discussed a problem for 4 min and then tried to "wrap up" in response to a signal (a perturbation). The perturbation was intended to increase the pressure on the dyad, triggering a reorganization of their behavioral system. We hypothesized that the comorbid group would be distinguished from the externalizing-only group as a result of this reorganization, but not before. The sequential data were analyzed using a combination of case-sensitive (state space grids and chi-square analyses) and group-based, multivariate techniques (log-linear modeling). Results revealed that externalizing dyads engaged in a permissive pattern throughout the problem-solving session, whereas comorbid dyads shifted from a permissive pattern to a mutually hostile pattern after the perturbation. These findings punctuate the need for a dynamic systems approach to the study of relationship processes associated with the development of childhood psychopathology. Theoretical and clinical implications are discussed.

KEY WORDS: dynamic systems theory; parent–child relations; aggression; comorbidity.

INTRODUCTION

The fundamental heterogeneity of aggressive youth has long been acknowledged (e.g., Hinde, 1992; Hinshaw & Zupan, 1997; Moffitt, 1993). A variety of structural/causal processes with distinct etiologies are thought to underlie a similar overt (aggressive) pattern (Cicchetti & Richters, 1993). Whereas this variability has been recognized theoretically, most empirical research continues to employ designs and methodologies that presume the homogeneity of aggressive children (e.g., Hinshaw, Lahey, & Hart, 1993; Richters, 1997). Moreover, little research has investigated the diversity of the family interactions of aggressive children. One pragmatic consequence of this neglect may be the continued variability in treatment outcome that has been reported with this clinical population (e.g., Brestan & Eyberg, 1998; Dumas, 1989; Kazdin, 1995; Southam-Gerow & Kendall, 1997). Uniform treatment approaches are unlikely to be relevant to children and families with diverse etiologies.

Two main objectives were addressed in this study. First, differences in family interaction processes of two hypothesized subtypes of aggressive children were examined. Epidemiological evidence suggests that a significant proportion of aggressive youth exhibit co-occurring internalizing (i.e., anxiety, depression) symptoms (for reviews, see Angold, Costello, & Erkanli, 1999; Zoccolillo, 1992). Thus, we looked for differences in the mother–child interactions of "pure" externalizing children (EXT) versus

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"mixed" (or comorbid[4]) internalizing and externalizing children (MIXED).[5]

The second objective was to introduce a new methodological strategy, based on dynamic (or dynamical) systems (DS) principles, which is particularly suited to the study of heterogeneous, interactional processes. DS principles were integral both for the design of this study, and for suggesting appropriate analytic strategies for testing the hypotheses statistically. The DS techniques, which are fundamentally case-based, were supplemented with a multivariate strategy derived from an established statistical tradition. The goal in combining these two approaches was to develop a rich description of the temporally organized, context-sensitive interaction patterns that might differentiate subtypes, while deriving a statistical test of the strength of these differences.

Differences in Subtypes' Parent–Child Interactions

Although there are probably a number of causal sources that contribute to the development of pure externalizing versus comorbid symptomatology (e.g., genetic influences, biological vulnerabilities), this study focused on the parent–child relationship. Parent–child interactions are one of the central factors implicated in the development of childhood psychopathology in general (e.g., Dadds, 1987; Maccoby & Martin, 1983); thus, following other researchers, we hypothesized that unique parent–child processes may correspond to different clusters of childhood symptomatology (Capaldi, 1991, 1992; Capaldi & Stoolmiller, 1999; Dadds, Sanders, Morrison, & Rebgetz, 1992; Donnenberg & Weisz, 1997; Sanders, Dadds, Johnston, & Cash, 1992).

Only a handful of studies have investigated the possibility that unique parent–child processes differentiate EXT and MIXED children. Capaldi (1991, 1992) and Capaldi and Stoolmiller (1999) compared the family management practices of parents with EXT and MIXED adolescents and found no differences; both groups shared the same experiences of hostile and ineffective discipline and strong parental rejection. But there are some limitations of this research that may have precluded finding differences. The assessment of parent–child relations was on the basis of questionnaires and global ratings that may have been too coarse to pick up differences. Moreover, because the measures were unconcerned with temporal processes (i.e., global, summary ratings of observational sessions were used, as opposed to some form of sequential or time-series analysis), important relationship dynamics may have been overlooked.

In contrast, two studies by Dadds, Sanders, and their colleagues (Dadds et al., 1992; Sanders et al., 1992) suggested interactional differences between EXT and MIXED dyads. In their studies, EXT children had family interactions marked by aversive, angry affect compared to the MIXED group who showed a conspicuous lack of hostility and, instead, showed elevated levels of depressed affect. Finally, Donnenberg and Weisz (1997) showed that both EXT and MIXED parent–child interactions varied across contexts (i.e., conflict versus cooperative activity), but groups differed only in their interactions during the conflict task. These latter results highlight the role of context in problem-solving interactions.

In sum, it remains unclear whether MIXED and EXT parent–child interactions really do differ. But these studies suggest directions for further inquiry. Specifically, it seems critical to measure the temporal patterning of dyadic behavior (rather than rely on questionnaires or global ratings) and to pay attention to the context within which this behavior is embedded. These points have been emphasized by many theorists (e.g., Bronfenbrenner, 1979, 1986; Dishion, French, & Patterson, 1995; Hinde, 1992; Sameroff, 1983; Sroufe, 1989), but there remains relatively little empirical work that systematically measures dynamic factors associated with behavioral variability. One reason for this neglect may be the lack of an appropriate methodological toolkit. As many developmentalists have noted, the DS framework has the potential to provide needed tools (Dumas, Lemay, & Dauwalder, 2001; Fogel & Thelen, 1987; Granic, 2000; Keating, 1990; Lewis, 1997; Lewis & Granic, 1999, 2000; Thelen & Smith, 1994).

Conceptual Framework

DS theory is a mathematical language that can be used to study how novel forms emerge and stabilize

[4]For purposes of simplification, comorbidity and co-occurrence are used interchangeably; technically, comorbidy refers to the presence of two or more *diagnosed* disorders (e.g., conduct disorder and depression).

[5]There is a perennial debate among researchers about whether the "narrowband" factors of depression and anxiety can be distinguished from one another or whether they represent one "broadband" internalizing cluster of symptoms. There is strong evidence that the associations between aggression and depression actually occur between the broadband externalizing and internalizing levels (e.g., Achenbach, 1991a; Achenbach, Conners, Quay, Verhulst, & Howell, 1989; Quay, 1986; Weiss, Jackson, & Susser, 1997; Weiss & Catron, 1994; Wolfe, et al., 1987; Wright, Zakriski, & Drinkwater, 1999). Also, because little discriminant validity has been found between the constructs of childhood depression and anxiety (e.g., Kazdin, Esveldt-Dawson, Unis, & Rancurello, 1983; Patterson, Greising, Hyland, & Burger, 1997; Wolfe et al., 1987), we chose to focus on the broadband indicators.

through a system's own internal feedback processes (Prigogine & Stengers, 1984). This process is known as *self-organization* and refers to the spontaneously generated (i.e., emergent) order in complex, adaptive systems. For a more detailed explanation of DS principles, and their relevance to developmental psychology, the reader is referred to reviews by Thelen and Smith (1994), Fogel (1993), and Lewis (2000).

For the purposes of this study, we will be using DS theory as a conceptual framework that suggests specific hypotheses and methodological directions. We are not suggesting that there are precise mathematical equations that can describe aggressive children's parent–child relations. Instead, following other developmentalists (e.g., Fogel, 1993; Keating, 1990; Lewis, 1995, 1997; Lewis & Granic, 2000; Thelen & Smith, 1994), we have found that the mathematical concepts have important heuristic value. In particular, the DS framework is attractive because it addresses some of developmentalists' most central concerns, namely the fundamental heterogeneity, the context-dependent quality, and the temporal nature of complex developmental phenomena (Lewis, 2000; Lewis & Granic, 1999). Moreover, a number of design and analytic strategies are suggested by this approach and two of these were applied to understanding differences between MIXED and EXT dyads.

State Space

A state space is a model of all possible stable states a system can attain—a topographical map of a system's behavioral repertoire. To remain consistent with other DS theorists, we refer to these stable states as *attractors*; they are regions of the state space toward which behavior tends to be drawn. Over development, attractors represent recurrent patterns that have become predictable; all developmental acquisitions can be described as attractor patterns that emerge over weeks, months, or years (Thelen & Smith, 1994). Importantly, however, living systems are characterized by *multistability* (Kelso, 1995); their state space includes several coexisting attractors and they can end up in one or another.

Recurrent patterns of parent–child interactions can be conceptualized as *dyadic* attractors that emerge over development (e.g., Fogel, 1993; Fogel & Thelen, 1987). For example, Patterson, Snyder and their associates (e.g., Patterson, 1982; Snyder, Edwards, McGraw, Kilsgore, & Holton, 1994) have discussed "coercive cycles" as aversive, self-perpetuating patterns of interaction that recur over time. For a particular dyad, this coercive pattern may be one interaction style that has stabilized over development. But this dyad may have also developed a cooperative pattern of interacting and a mutually sad and withdrawing pattern, for example. Most research on aggressive parent–child interactions has identified either negative *or* positive patterns, but even severely aggressive dyads sometimes engage in positive or neutral interactions and the most healthy dyads have hostile arguments. One of the advantages of a DS analysis is that several unique interaction patterns on a state space can be examined *concurrently* and their relation to one another can be explored. Thus, the concept of a state space highlights this multistability and suggests that critical information may be gained in modeling the conditions under which dyads move from one type of interaction pattern to another. This may be a particularly useful strategy for fine-grained identification of differences between subtypes of aggressive children and parents.

Moreover, this approach may provide a means of further parsing interaction processes that have previously been assumed to represent one coherent pattern. Particularly relevant for our purposes is the coercive process, which we suggest may actually constitute two separate microsocial patterns of interactions—two separate attractors on a state space. The first involves the parent who, in response to her child's increasingly aversive, noncompliant behavior, withdraws her demands and tries to appease her child in order to end his continued hostile behavior. After hundreds of similarly repeated interactions the parent sets fewer limits and often responds in a neutral or even positive manner to the child's aversive behavior. We refer to the real-time sequence of behaviors (child negative–parent positive or neutral) as *permissive* (e.g., Baumrind, 1971); it also has been labeled inconsistent or indiscriminant parenting (Dumas & LaFreniere, 1993, 1995). The second interaction pattern constituting coercion has been referred to as *mutual hostility*, when each dyad member responds to the other with escalating criticism, contempt and hostility (Patterson, 1982; Patterson, Reid, & Dishion, 1992; Snyder et al., 1994). In this study we examined the coercive pattern as including two separate regions on a dyadic state space; we were interested in investigating the conditions under which dyads would be drawn toward one region or the other, and if these conditions differed for subtypes.

Perturbation and Change

The second strategy was to capture the tendency for dynamic systems to become reorganized in response to small changes in context—or *perturbations*. These perturbations have the potential to abruptly "push" the system from one stable pattern to another (Fogel, 1993; Thelen & Smith, 1994). But this is only a potential—whether and how a system becomes reorganized is determined by its underlying structure. DS researchers often observe changes in system behavior, as it varies with contextual forces, in order to infer this structure (e.g., Fogel, 1993; Lewis & Granic, 1999; Thelen & Smith, 1994; Thelen & Ulrich, 1991). We examined the possibility that mutual hostility and permissiveness expressed key structural characteristics of dyadic interactions that could best be tapped by perturbing the system. Thus, a shift from one region (attractor) to another, in response to a perturbation, might reflect structural differences between MIXED and EXT dyads.

As others have noted (e.g., Dumas et al., 2001; Sameroff, 1995), many DS concepts are not new to developmentalists. For example, the tenet that behavior is always temporally organized and context-dependent is central to the transactional perspective (Bronfenbrenner, 1979, 1986; Hinde, 1992; Sameroff, 1983; Sroufe, 1989). From both perspectives, the search for distinctive dyadic interaction patterns requires a focus on sequential behavior (e.g., by direct observation) and on the context in which it is embedded. But the DS framework further suggests particular research designs and analytic tools for examining these dynamic features. According to this approach, the best way to tap potential differences in underlying structural characteristics is by perturbing the parent–child system and observing its reorganization in response. We propose that one reason structural differences between subtypes' parent–child relations may not have been consistently identified is because no studies have attempted to perturb interaction patterns to assess alternate stable states.

Rationale and Overview of Design

This study was based on a problem-solving paradigm identical to those in the studies reviewed previously, except for one critical difference—a perturbation was introduced part-way through the problem-solving session in order to elicit a potential reorganization in dyadic behavior. Specifically, a knock on the door was used as a signal to the dyad that they were running out of time and that they needed to quickly and amiably resolve their differences. This perturbation was intended to raise the "emotional ante," mimicking naturalistic episodes in which one or both partners suddenly feels anxious to resolve a particular conflict. For instance, parents often start feeling embarrassed in public places (e.g., bank, supermarket) when an argument begins to escalate, they perceive others watching, and they are unable to control their child.

The procedure was based on two conceptual premises. The first, held by many developmental psychopathologists, was that individual differences are best tapped under stressful conditions. By increasing dyads' arousal levels, thoughtful problem-solving strategies may be interrupted. As a result, the parent and child may rely on overlearned, automatic response patterns that have stabilized over development across similarly repeated episodes. Thus, dyadic patterns that may not have otherwise been identified may emerge as a result of changing the emotional context. When attachment researchers administer the Strange Situation—a series of mother–child separations and reunions—in order to assess differences in individual and dyadic behavior, they are relying on a similar premise. MIXED and EXT dyads might be expected to differ in the extent to which they perceive the emotional pressure and the style with which they react.

The second premise was based on the simple DS principle that stipulates that only by perturbing a system can the range of behavioral possibilities be identified. In other words, perturbing the systems is thought to reveal its underlying structure. Thus, it was the *reorganization* of dyadic patterns that was expected to differentiate MIXED and EXT parent–child interactions.

Research Questions

Two research questions were investigated: (1) Can structural differences in interaction patterns be detected by using the standard family problem-solving paradigm, or are they better accessed by perturbing the interaction and observing dyads' behavioral responses? It was expected that EXT and MIXED dyads would show similar interaction patterns before the perturbation, but that they would appear distinct on the basis of their response to the perturbation. (2) What is the specific nature (i.e., the content) of this change in interaction patterns for each subtype and what might it suggest about their different etiologies? Given the lack of previous research, no specific hypothesis was made, but the permissive and hostile patterns associated with Patterson's coercion model provided a direction for exploratory analysis. These questions were investigated through two complementary analytic strategies: (1) State space grid analysis, a DS, case-based technique that displays sequential data graphically and (2) Log-linear analysis, a multivariate, group-based analytic strategy that can be used to statistically test the impressions gained from the state space grids.

METHOD

Participants

Parents and children were recruited from two treatment programs for aggressive children in an urban psychiatric institute. At the intake stage of these treatment programs, the experimenter approached families, introduced the study, and asked if they wanted to participate in a videotaped problem-solving discussion. Families were offered $20.00 and a toy for participating. All but one family agreed to participate. Child participants were 36 boys between 8 and 12 years of age ($M = 9$ years, 11 months), referred by either a mental health professional, teacher, or parent. Mothers of referred children also participated in the study. Based on the number of girls referred in previous years to the intervention programs, it was not expected that there would be a large enough sample to explore gender differences; thus, girls were excluded from the study a priori. (During the span of this study, only five girls were referred to the programs from which children were recruited.) To be included in the study, boys had to score within the clinical range (98th percentile) on the Externalizing subscale of either the *Child Behavior Checklist* (CBCL; Achenbach, 1991a) or the *Teacher Report Form* (TRF; Achenbach, 1991b). Mothers and children needed to have sufficient command of the English language to complete questionnaires without an interpreter. The child had to be currently living with the mother and to have been in the home for at least 1 year prior to the assessment. Children were excluded if they were diagnosed as mentally handicapped or if they had a pervasive developmental disorder. Children were classified into two distinct groups—MIXED and EXT—based on a combination of information from the CBCL and TRF, as detailed in the next section.

Three boys were excluded from the sample for various reasons: one child's mother spoke Chinese throughout the problem-solving session, one dyad had audio failures during the videotaping, and one was omitted because the mother spoke the entire session except for one short utterance from the child. The participants in the final analyses included 33 dyads, 14 EXT, and 19 MIXED.

In terms of demographic information, 26 of the children (78.8%) were Caucasian, 2 (6.1%) were Caribbean-Canadian, 4 (12.1%) were mixed Caucasian/Caribbean-Canadian, and 1 (3%) was Indian. In terms of parents' marital status, 10 (30.3%) were single (never married), 9 (27.3%) were married, 3 (9.1%) were separated, and 11 (33.3%) were divorced. Finally, socioeconomic status was estimated by the highest level of education attained by the mother. Two parents (6.1%) had completed up to Grade 8, 13 (39.4%) had completed high school, 9 (27.3%) had completed some college or vocational training, 3 (9.1%) graduated from college, and 4 (12.1%) had completed graduate or professional school. Data on socioeconomic status for two mothers were unavailable.

Classification Criteria

Classification of children was based on a combination of information from the CBCL and TRF. Before describing this strategy, descriptive information on the sample is provided separately by informant. In terms of the full sample, means on the CBCL Externalizing and Internalizing scales were 70.94 ($SD = 9.16$) and 62.10 ($SD = 14.83$), respectively. On the TRF, means on the Externalizing and Internalizing scales were 70.93 ($SD = 8.45$) and 63.43 ($SD = 12.01$), respectively. In terms of the association between parent- and teacher-reported symptoms, there was no significant correlation on either the Externalizing ($r = -.16$) or the Internalizing subscales ($r = .29$) of the CBCL and TRF. Based on parents' reports, 76.8% (24) of the participants reached the clinical cutoff on the Externalizing subscale and 48% (15) reached the cutoff on the Internalizing subscale. Based on teachers' report, 54.5% (18) of the participants reached the clinical cutoff on the Externalizing subscale and 27.3% (9) reached the cutoff on the Internalizing subscale. Parents and teachers agreed that four boys had clinically elevated levels of externalizing problems only (EXT) and that four boys had clinically elevated levels of both externalizing and internalizing problems (MIXED). Thus, about 25% (8) of the participants exhibited consistent clinically significant problems in both home and school settings.

To qualify for the "*Pure*" *Externalizing* (EXT) group, children were required to score at or above the clinical cutoff ($T \geq 70$) on the Externalizing scale of *either* the CBCL or the TRF, and to score below this cutoff on the Internalizing scale on *both* the CBCL and TRF. Children qualified for the "*Mixed*" *Externalizing and Internalizing* (MIXED) group if they scored at or above the clinical cutoff ($T \geq 70$) on the Externalizing scale of *either* the CBCL or the TRF *and* scored above this cutoff on the Internalizing scale on *either* the CBCL or TRF. This simple combinatorial strategy has been shown to approximate best-estimate diagnoses made by clinicians (e.g., Bird, Gould, & Staghezza, 1992) and to be just as effective as more elaborate strategies, including logistic regression techniques (see Offord et al., 1996, for a review).

There was one CBCL that was incomplete and five TRFs that were not returned. For these cases, the classification was based on the checklist that was available.

Table I. Means and Standard Deviations on CBCL and TRF Scores by Group

Measure	EXT ($N = 14$) *M*	*SD*	MIXED ($N = 19$) *M*	*SD*
CBCL				
Externalizing	68.62 (13)	8.50	72.61 (18)	9.48
Internalizing***	51.62 (13)	11.88	69.67 (18)	12.00
TRF				
Externalizing	70.58 (12)	7.51	71.19 (16)	9.32
Internalizing***	55.92 (12)	6.97	69.06 (16)	12.05

Note. Number of measures available for each mean is shown in brackets.
$^{***}p < .001$.

Using the criteria described, 14 children were categorized as EXT and 19 were categorized as MIXED. Means and standard deviations for the Externalizing and Internalizing *T*-scores on the CBCL and TRF are presented separately for each group in Table I. Supporting the internal validity of our groups, *t*-test comparisons showed no significant group differences on the Externalizing scales, but strong differences on the Internalizing scales on both the CBCL, $t(29) = 4.16$, $p < .001$, and TRF, $t(26) = 3.63$, $p < .001$.

Procedure

Parents and teachers were sent standardized measures of children's problem behaviors in the mail before arriving at the clinic. The experimenter met with each parent and child approximately 2 weeks prior to the beginning of a treatment program, collected the completed forms, and explained the procedure. We adapted Forgatch, Fetrow, and Lathrop's procedure for studying problem-solving in families of antisocial children (Forgatch et al., 1985). Among other questionnaires, the parent and child completed a modified version of the *Issues Checklist* (Robin & Weiss, 1980) which lists a number of potential sources of conflict between parents and children (e.g., bed time, lying, swearing). The experimenter chose two issues from these questionnaires for the problem-solving sessions. For the first interaction, dyads discussed an issue that both participants nominated as moderately problematic. For the second interaction, dyads discussed an issue that they agreed was one of their most problematic. The first interaction was designed as a warm-up session, to allow dyads to become accustomed to the task. The second was intended to be more emotionally arousing and, for most dyads, it was this session that was later analyzed. But based on a previous pilot study, it was expected that a small number of dyads would be more emotionally engaged in the first session. This happened for various reasons, the most common of which was that the dyad became completely disengaged in the second session, ignoring instructions and either eating, singing, or playing a game. For these dyads, the first session was analyzed instead of the second (details on how these decisions were made is provided in the Results section).

Participants were asked to interact naturally, to speak to each other and not to the camera, and to avoid feeling compelled to explain events to the experimenter (or the camera). The parent and child were then told to face each other and discuss, with the intent to resolve, the first issue. They were told that they would have 6 min to try to resolve the conflict and that after 4 min, they would hear a knock on the door (the *perturbation*). They were told that the knock was their signal to try to "wrap up, resolve the conflict for good, and end on friendly terms." The procedure was repeated immediately with the second topic. Interactions were videotaped from behind a one-way mirror and coded for affective content using a combination of modified versions of standardized coding systems (described later).

Measures

Child Behavior Checklist (CBCL; Achenbach, 1991a)

The CBCL is a standardized, highly reliable and valid measure of children's emotional and behavioral problems. Parents are asked to indicate whether, and to what degree, their child exhibits a list of symptoms. The instrument yields standardized *T*-scores for Total Behavior Problems, Internalizing Problems, and Externalizing Problems.

Teacher Report Form (TRF; Achenbach, 1991b)

The TRF is a parallel measure to the CBCL that is completed by the child's teacher. It is also a standardized, highly reliable and valid measure and generates the same broadband *T*-scores as the CBCL.

Issues Checklist (Robin & Weiss, 1980)

A slightly modified version of the Issues Checklist was included to assess the most frequently and intensely discussed family issue, according to the parent and child. The original version of this questionnaire was designed to be relevant for adolescents and parents; it included 44 items of potential conflict. For this study, some of the items that related primarily to adolescent issues were deleted or replaced with more appropriate items for 8–12 year-olds (e.g., "going on dates" was replaced with "talking back to teachers" and "sex" and "drugs" were deleted). Parents and children were asked to recall disagreements about several issues including lying, bed-time, and so on, and to report the frequency and intensity of these discussions (on a 5-point Likert scale). For each item, the experimenter multiplied the frequency score by the intensity value and the topic with the highest frequency by intensity product on both the parent and child forms was designated the topic for the second discussion. If there were any discrepancies (i.e., if the parent rated a topic high on conflict but the child rated the same topic as low), the experimenter chose the parent's high conflict topic. For the first discussion, a topic that dyad members agreed was moderately conflictual was discussed, that is, a topic that was not rated lowest or highest on either participant's checklist.

Coding Procedures

We used a modified version of Robin and Weiss' variation (Robin & Weiss, 1980) on the Marital Interaction Coding System (Weiss, Hops, & Patterson, 1973). The coding scheme was designed to classify verbal and nonverbal behaviors using 19 codes, and these were amalgamated into four categories that fell on a continuum from positive to hostile (positive, neutral, negative, and hostile). The amalgamation strategy was based on Snyder and colleagues' dimensional system (Snyder et al., 1994) in which they categorized ratings of parent–child behaviors along a 10-point continuum from *most positive* (0) to *most aversive* (9).

Only one positive category was used because they occurred very infrequently (across all groups, only 1% of children's codes and only 5% of parents' codes were positive). Codes included as "positive" were: approve, agree, elicit opinion, humor, offer solution, consequential statement, and polite request for compliance. Neutral codes included: exchange information, answer, question, listen. Informed by the Snyder et al. system, negative codes were separated into two categories, negative and hostile. This was done to distinguish behaviors that might be considered negative but not hostile or contemptuous (i.e., disagree, deny) from those behaviors that were intended to attack, diminish or degrade the other (i.e., criticize, threaten). Primarily, the difference between these two categories was the affect with which behaviors were expressed: negative behaviors were accompanied with either neutral or mildly negative affect whereas hostile behaviors were expressed with strong negative affect or hostility. Four codes fell into the negative category: disagree/deny, rhetorical teaching/leading question, command, and ignore/evade. Finally, six codes were categorized as hostile: interrupt with hostile tone, sarcasm, irritation, noncomply,[6] complain/criticize/accuse, and threaten. Coders were instructed to consider the content and the affective valence (based on the tone of voice, body posture, and facial expression of each participant) of each conversational turn.

Observers and Reliability

Two undergraduate students were involved in coding the videotaped interactions. Both students were blind to the purposes and hypotheses of the study. Coders were trained until they reached 90% agreement. The training was conducted on early pilot data collected the previous year; these data were not included in this study. One student coded all the videotapes. The second student coded 10 (approximately 30%) randomly selected problem-solving sessions for the purpose of calculating interrater reliability. Cohen's kappa was computed separately for each of the four mother and child codes. For the child codes, the following kappas were obtained: .29 for positive, .72 for neutral, .63 for negative, and .63 for hostile. For the parent codes, the kappas were: .42 for positive, .72 for neutral, .63 for negative, and .53 for hostile. The reliability was considered acceptable (Fleiss, 1981) for all codes except for the positive codes; it is likely that the reliability for these codes was low because they occurred with very low frequency. None of our analyses relied on the distinction between the positive and neutral categories, thus, we decided to include the positive category (and not collapse it into another category), despite poor reliability, for descriptive purposes.

DATA ANALYSIS AND RESULTS

Preliminary Analyses

To ensure that groups did not differ on any demographic variables, ANOVAs and chi-square analyses were

[6]"Noncomply" was categorized as "hostile" based on Snyder et al's system which rated "noncomply" with negative affect as an 8 out of 9 on the aversiveness scale (a code of 9 was assigned to behaviors such as verbal and physical attack). In the current system, "noncomply" was coded "hostile" only if the behavior was accompanied by negative affect, otherwise it was coded as "disagree" or "ignore/evade."

conducted. A series of one-way ANOVAs were performed on mother's age ($M = 35$ years) and child's age ($M =$ 9 years, 11 months). Chi-square analyses were performed on three categorical variables: (1) ethnicity, (2) mother's highest level of education, and (3) parent's marital status. No significant differences were found on any of these comparisons.

A manipulation check was conducted for each dyad, comparing the first and second problem-solving sessions, to ensure that analyses were run on data from the most emotionally arousing session. As discussed in the procedures section, the first session was intended to be a warm-up session and the second session was the one intended for analysis. But some dyads became disengaged from the task in the second session, choosing to sing, eat, or play a game (most of which would be coded as "neutral" or "positive"). Thus, as decided on the basis of pilot data, the observed rate of "negative" and "hostile" codes was calculated for each dyad and each session. For 7 dyads (4 MIXED and 3 EXT), the frequency of these codes was higher in the first session than in the second. For these dyads, the first session was analyzed instead of the second.

State Space Grid Analysis

State space grids (Lewis, Lamey, & Douglas, 1999), a new dynamic systems method that graphically represents behavior as it proceeds in real time, was adapted for this study. This method offers an intuitively appealing way to view complex, interactional behavior, by displaying how behavior clusters in certain regions of a state space and changes over time. Thus, this method can capture dyads' movement between regions of the state space, providing a rich case-by-case temporal narrative for exploratory analysis.

In these grids, the parent's behavior is represented on the *x*-axis and the horizontal lines represent her conversational turns. The child's behavior is represented on the *y*-axis and vertical lines depict each of his conversational turns. Each point on the grid represents a two-event sequence (i.e., a dyadic state) and these are partially overlapped in that the last turn of one sequence is also the first turn of the next sequence (i.e., each code is considered consequent in one turn and antecedent in the next). Thus, each line on the grid represents an individual's behavior, and each point is a dyadic sequence. A hypothetical trajectory representing seven conversational turns is presented in Fig. 1. Beginning with the point labeled "start," the following seven events are plotted: child neutral, parent neutral, child hostile, parent neutral, child hostile, parent hostile, and child hostile. The two shaded regions on the grid represent the regions of theoretical interest: mutual hostility and permissiveness.

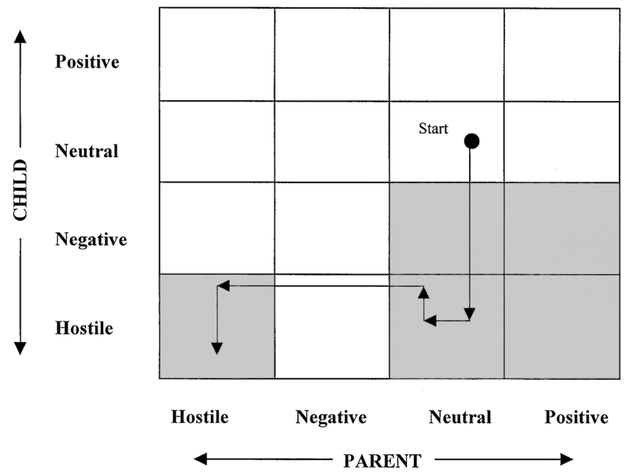

Fig. 1. Example of a state space grid with a hypothetical trajectory representing the following seven events: child neutral, parent neutral, child hostile, parent neutral, child hostile, parent hostile, and child hostile.

State space grids were constructed for all dyads by arranging adjacent codes as x-y coordinates and plotting them along a timeline within the grid template. Separate grids were constructed for the pre- and postperturbation periods. For this study, the lines (trajectories) are less important than the points which show clustering in particular cells. For the purposes of presentation, one characteristic dyad is shown from each group. As exemplified in Fig. 2, EXT dyads tended to go to the permissive region of the state space grid, as well as other regions (i.e., mutual neutrality and negativity), before the perturbation. After the perturbation, EXT dyads tended to remain and stabilize in the permissive region. Figure 3 represents the interaction of a MIXED dyad. Similar to EXT dyads, the MIXED dyads occupy the permissive region, as well as other areas, before the perturbation. But in the postperturbation grids, MIXED dyads showed a different pattern. In contrast with the EXT group, MIXED dyads tended to move to the mutual hostility, or mutual negativity, region of the state space grid, as shown.

To confirm this descriptive analysis quantitatively, for each group, we compared the proportion of dyadic points in the permissive region versus the mutually negative/hostile region, for the pre- and postperturbation periods separately. Because each dyadic point on the state space grids represented a two-event transition, this procedure was akin to calculating and comparing conditional

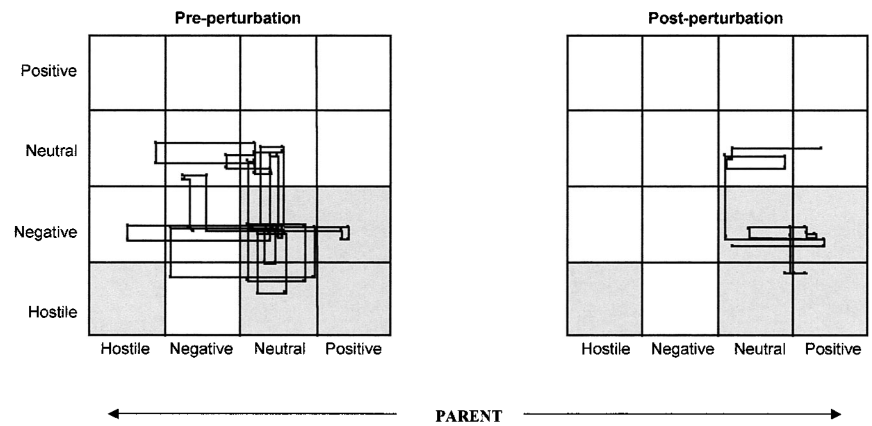

Fig. 2. Pre- and postperturbation state space grids for an EXT dyad.

probabilities. Thus, all instances of child negativity or hostility (Code 3 or 4) were identified, and the conditional probability that the parent would respond immediately (Lag1) with a positive or neutral behavior (Code 1 or 2) was computed. Dyads were then assigned one of two categorical codes depending on whether this conditional probability increased/stayed the same or decreased after the perturbation. If it increased or stayed the same, a dyad was classified as *no shift*; if it decreased after the perturbation, it was classified as *shift to hostility*. The difference in conditional probabilities had to be at least .05 to be considered a change, to eliminate spurious assignments. Finally, the Pearson chi-square statistic was computed to compare the frequency of shifts for MIXED and EXT dyads. Results revealed a significant association, $^{2} = 7.16$ (1), $p < .007$, with 86% of EXT dyads showing no shift to the mutual hostility region after the perturbation and 14% showing a shift versus 63% of MIXED dyads who showed a shift and 37% who did not.

Log-Linear Analysis

In the second phase of the analyses, the results obtained from the case-by-case state space grid analysis were further tested using a multivariate approach which combined log-linear and hierarchical log-linear modeling procedures (e.g., Bakeman, Adamson, & Strisik, 1995; Bakeman & Gottman, 1997; Bakeman & Quera, 1995). Unlike basic lag-sequential analysis, log-linear approaches allow sequential questions to be examined through the lens of an established statistical tradition. Log-linear analysis is similar to the familiar chi-square analysis, but it is not restricted to two-dimensional tables. The procedure

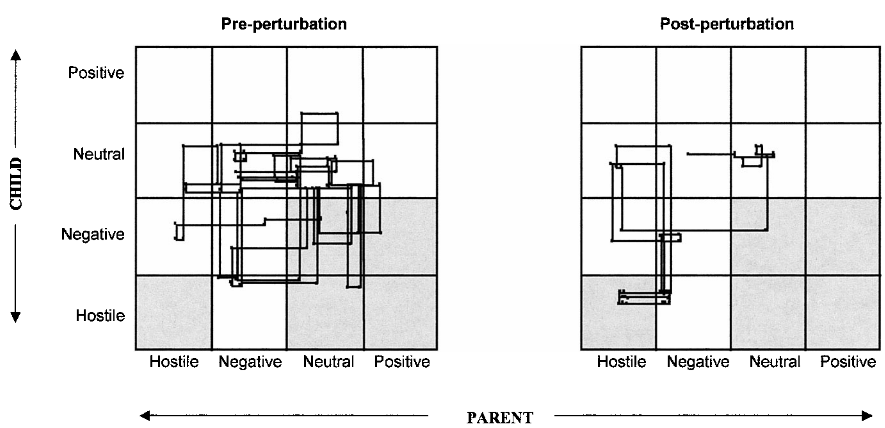

Fig. 3. Pre- and postperturbation state space grids for a MIXED dyad.

examines higher-order interactions (3-way, 4-way interactions, etc.) between multilevel categorical variables and identifies the transitions that account for these interactions.

Overlapped sampling, the most common format for analyzing sequential data (Bakeman & Quera, 1995), was used for the first set of log-linear analyses.[7] Through this sampling procedure, antecedent (Lag0) and consequent behaviors (Lag1) are two of the categorical variables in the multiway contingency table. Thus, cells represent frequency counts of specific parent–child and child–parent transitions. A third categorical variable was labeled "Partner"; this factor referred to the particular dyad member at Lag0 and Lag1. The models tested across all analyses included a combination of three or more of the following variables: Lag0 (behavior of child or parent at time t: Positive, Neutral, Negative, or Hostile), Lag1 (behavior of child or parent at time $t + 1$: Positive, Neutral, Negative, or Hostile), Partner (dyad member considered as antecedent or consequent: Parent, Child), Group (EXT, MIXED), and Period (preperturbation, postperturbation). Each two-event sequence was categorized according to each of the factors.

Question 1: Group Differences Based on the Perturbation

Hierarchical log-linear modeling[8] was employed to address the first research question: Do dyadic subtypes differ in parent–child interactions and are these differences due to the perturbation? As indicated by the state space grids, MIXED, but not EXT, dyads changed their patterns of interaction *after being perturbed*. To confirm this exploratory result, separate hierarchical modeling procedures were run for each group.

The saturated model that began the hierarchical procedure for each group was the 4-way interaction, Lag0 × Lag1 × Period × Partner. As shown in Table II, there was no change in dyadic behavior (Lag0 × Lag1) by Period for the EXT group—the parent's and child's behavior (Lag0 × Lag1) were associated with each other and varied according to who was considered the antecedent, but these associations were independent of Period. One or both EXT dyad members' independent behaviors varied according to Period, but there were no such changes evident in the *interaction patterns*. In contrast, the MIXED group did show a 3-way interaction with Period (i.e., Lag0 × Lag1 × Period), indicating that parent–child interactions changed from pre- to postperturbation.

Table II. Final Models Developed for each Group Separately

Final log-linear modeling interaction	Δdf^a	ΔG^{2a}	p^a
EXT ($n = 1645$)[b]			
Partner × Lag0 × Lag1	9	38.70	<.0000
Lag0 × Period	3	21.93	<.0001
Lag1 × Period	3	21.12	<.0001
MIXED ($n = 1866$)[b]			
Lag0 × Lag1 × Period	9	31.58	<.0002
Partner × Lag0	3	164.51	<.0000
Partner × Lag1	3	162.68	<.0000

[a] Values represent the *change* in *df*, G^2, and the *p*-level associated with this change if the interaction was deleted from the model.
[b] Sample size refers to the number of cases, not dyads.

But was the change observed for the MIXED dyads discontinuous, in direct response to the perturbation, or did they change simply as a function of time? Although it may still be interesting if subtypes gradually become distinct in their interaction patterns, this was not the underlying premise of this study. Instead, based on DS principles, it was hypothesized that subtypes would look similar until the dyadic system was perturbed. Thus, the following hierarchical modeling procedures were conducted.

The 6-min problem-solving sessions were split into three equal 2-min segments. The first two segments occurred preperturbation, the third postperturbation. The hierarchical analyses paralleled the first log-linear analysis, but instead of comparing only pre- and postperturbation periods, Segments 1 and 2 were compared first (both preperturbation) and Segments 2 and 3 were compared next (2 min before perturbation and 2 min after). Four factors were included in the saturated model that began the hierarchical procedure: Partner × Segment × Lag0 × Lag1. If the change that occurred for MIXED dyads was discontinuous due to the perturbation, then when only Segments 1 and 2 were considered, the Final model should show no 3-way interaction with Segment (Lag0 × Lag1 × Segment) but when Segments 2 and 3 are compared, a

[7] In this form of sampling, the events from which lags are computed are adjusted incrementally over the series. Thus, for each two-event sequence, each behavior was considered consequent for the first sequence and antecedent for the next sequence; in this way, a "floating window" of two-event sequences was developed.

[8] In this procedure, the researcher starts with a model that contains all possible interactions (the saturated model). Then, through a procedure of backward elimination, one by one the higher-order interactions that do not explain the observed frequencies (in the case of sequential data, the frequencies are transitional probabilities) are eliminated. The "final" or "best" model is one that suitably fits the observed frequencies and also contains the fewest necessary parameters (Bakeman & Robinson, 1994). By definition, the next backward step in the hierarchical procedure would result in a model in which the observed frequencies differ significantly from the expected (modeled) frequencies, yielding a significant increase in the likelihood ratio chi-square (indicated by a significant *p*-level).

Table III. Final Models for the MIXED Group Testing Differences Between Segments

Final log-linear modeling interaction	Δdf^a	ΔG^{2a}	p^a
Segment 1 vs. 2 Comparisons ($n = 1160$)[b]			
Partner × Lag0 × Lag1	9	20.71	<.01
Segment	1	5.52	<.02
Segment 2 vs. 3 Comparisons ($n = 1183$)[b]			
Lag0 × Lag1 × Segment	9	21.22	<.01
Partner × Lag0	3	135.34	<.0001
Partner × Lag1	3	136.98	<.0001

[a]Values represent the *change* in *df*, G^2, and the *p*-level associated with this change if the interaction was deleted from the model.
[b]Sample size refers to the number of cases, not dyads.

Table IV. Frequencies of Parent and Child Codes by Period

		N (%)			
		Parent		Child	
Group	Code	Pre	Post	Pre	Post
EXT	Positive	34 (.07)	46 (.16)	5 (.01)	7 (.03)
	Neutral	246 (.50)	144 (.51)	229 (.48)	138 (.50)
	Negative	86 (.18)	51 (.18)	27 (.06)	14 (.05)
	Hostile	122 (.25)	40 (.14)	218 (.46)	118 (.43)
	Sum	488	281	479	277
MIXED	Positive	59 (.10)	38 (.11)	14 (.02)	8 (.02)
	Neutral	330 (.53)	158 (.46)	267 (.44)	144 (.42)
	Negative	100 (.16)	93 (.27)	39 (.06)	22 (.06)
	Hostile	128 (.21)	53 (.16)	285 (.47)	167 (.49)
	Sum	617	342	605	341

3-way interaction with Segment would appear. As shown in Table III, results supported our hypothesis. In the first set of comparisons there were no associations between parent–child transitions (Lag0 × Lag1) and Segment. In contrast, an interaction between Lag0, Lag1, and Segment did emerge in the comparisons of Segments 2 and 3. These results suggest that the changes in MIXED dyadic patterns were discontinuous in response to the perturbation. In summary, the first set of findings supported the first hypothesis and corroborated the state space grid results: aggressive subtypes differed in their parent–child interactions and these differences were evident only after the perturbation.

Question 2: Changes in the Content of Dyadic Interactions

The state space grid results suggested that the EXT dyads engaged in a permissive pattern both before and after the perturbation, whereas MIXED dyads changed from a permissive to a mutually hostile/negative pattern. In order to test this distinction, the next set of procedures was intended to specify the content of the parent–child transitions that significantly contributed to the final log-linear models obtained for each group. Descriptive statistics are presented in Tables IV and V. Frequencies and percentages of parent and child codes are presented separately by Period (pre- and postperturbation) and by group (MIXED, EXT) in Table IV. Table V shows the joint frequencies and conditional probabilities for all combinations of antecedent–consequent behavior; values are presented separately for pre- and postperturbation, by group. In some cases, there are minor discrepancies between the two tables because antecedents outnumber consequents due to truncation at breaks. The important values to

Table V. Joint Frequencies and Conditional Probabilities for all Combinations of Given–Target Behaviors by Period and by Group

		N (%)			
		EXT		MIXED	
Given	Target	Pre	Post	Pre	Post
C_Hostile→	P_Hostile	60 (.28)	14 (.12)	62 (.22)	42 (.26)
	P_Negative	38 (.18)	29 (.25)	46 (.16)	53 (.32)
	P_Neutral	94 (.44)	50 (.43)	139 (.49)	47 (.29)
	P_Positive	23 (.11)	22 (.19)	35 (.12)	22 (.13)
C_Negative→	P_Hostile	13 (.48)	3 (.21)	15 (.39)	3 (.14)
	P_Negative	10 (.37)	5 (.36)	8 (.21)	14 (.64)
	P_Neutral	3 (.11)	5 (.36)	11 (.29)	3 (.14)
	P_Positive	1 (.04)	1 (.07)	4 (.11)	2 (.09)
C_Neutral→	P_Hostile	44 (.19)	19 (.14)	45 (.17)	7 (.05)
	P_Negative	37 (.16)	15 (.11)	40 (.15)	22 (.16)
	P_Neutral	137 (.60)	82 (.61)	162 (.61)	99 (.71)
	P_Positive	9 (.04)	19 (.14)	17 (.06)	11 (.08)
C_Positive→	P_Hostile	0 (.00)	0 (.00)	3 (.21)	1 (.13)
	P_Negative	1 (.25)	1 (.14)	2 (.14)	2 (.25)
	P_Neutral	3 (.75)	4 (.57)	7 (.50)	4 (.50)
	P_Positive	0 (.00)	2 (.29)	2 (.14)	1 (.13)
P_Hostile→	C_Hostile	63 (.53)	17 (.43)	69 (.55)	35 (.67)
	C_Negative	12 (.10)	2 (.05)	19 (.15)	2 (.07)
	C_Neutral	43 (.36)	21 (.53)	35 (.28)	14 (.27)
	C_Positive	0 (.00)	0 (.00)	2 (.02)	1 (.02)
P_Negative→	C_Hostile	33 (.38)	29 (.59)	48 (.49)	57 (.63)
	C_Negative	9 (.10)	6 (.12)	9 (.09)	15 (.17)
	C_Neutral	42 (.49)	14 (.29)	39 (.40)	16 (.18)
	C_Positive	2 (.02)	0 (.00)	2 (.02)	2 (.02)
P_Neutral→	C_Hostile	103 (.42)	45 (.32)	136 (.42)	49 (.32)
	C_Negative	5 (.02)	5 (.04)	10 (.03)	3 (.02)
	C_Neutral	133 (.55)	84 (.60)	170 (.53)	97 (.64)
	C_Positive	3 (.03)	6 (.04)	7 (.02)	3 (.02)
P_Positive→	C_Hostile	19 (.63)	25 (.57)	32 (.54)	23 (.62)
	C_Negative	1 (.03)	1 (.02)	1 (.02)	2 (.05)
	C_Neutral	10 (.33)	17 (.39)	23 (.39)	11 (.30)
	C_Positive	0 (.00)	1 (.02)	3 (.05)	1 (.03)

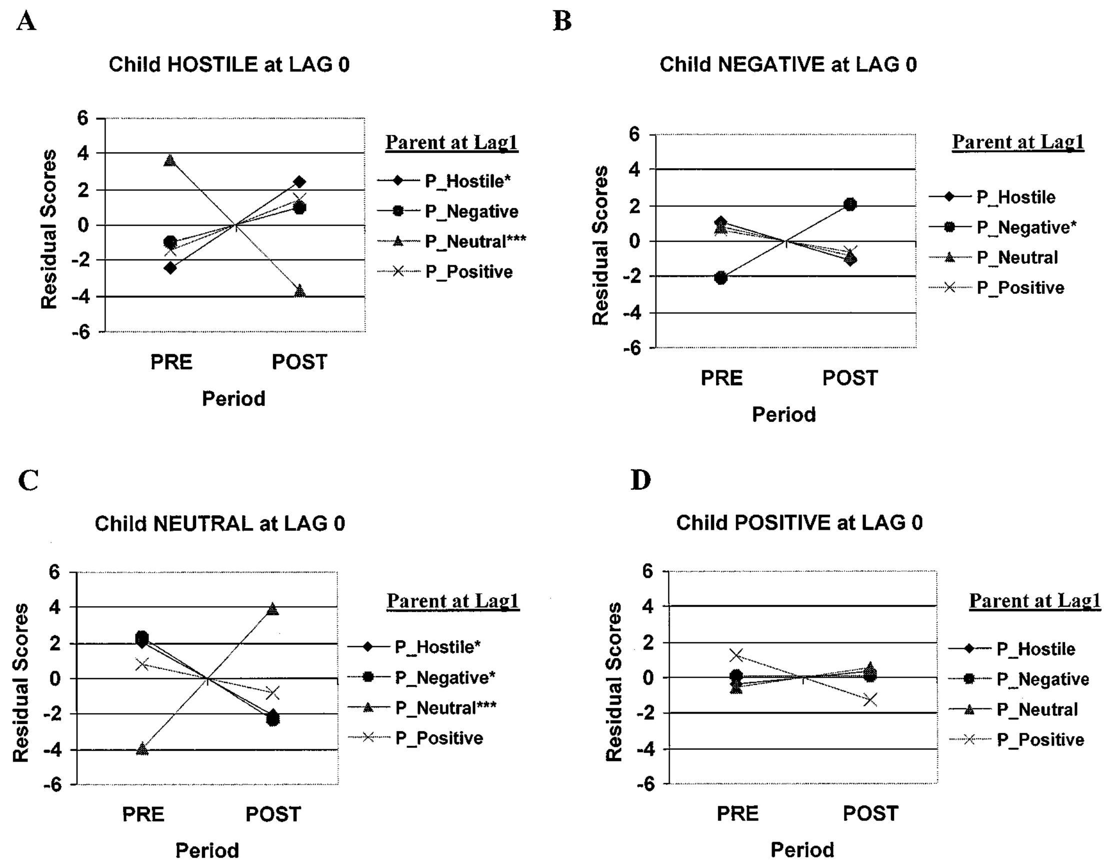

Fig. 4. Adjusted residuals for MIXED dyads when child's behavior is considered the antecedent and parent's behavior is the consequent. Adjusted residuals >|1.96|, |2.58|, and |3.30| are considered statistically significant at the *.05, **.01, and ***.001 level respectively. C_ = child's behavior; P_ = parent's behavior.

highlight in Table V are the conditional probabilities of parental response to child hostility (one indication of permissiveness). For both EXT and MIXED dyads, in the preperturbation period, parent neutral was the most common response to child hostility. This remained true only for the EXT dyads following the perturbation. Indeed, the Final model for the EXT group showed that there were no differences in parent–child (and child–parent) transitions before and after the perturbation; thus, no further analyses were conducted.

For the MIXED group, however, differences were revealed by the final model, and adjusted residuals were examined to identify the specific transitions responsible. Adjusted residuals are distributed approximately like *z*-scores but, unlike *z*-scores, they have the advantage of being computed independent of the number of tallies (Bakeman & Gottman, 1997; Haberman, 1978). These values were obtained by fitting the model that was one step *less* complex than the final model obtained through the previous hierarchical procedure (see Table II). In other words, this procedure asks: Why is the less complex model a poor fit? What cells deviate from the expected values and, thus, require a more complex model to explain the observed data?

The state space grids for the MIXED group seemed to indicate that parent–child transitions changed from a permissive pattern before the perturbation to a mutually hostile or negative one after. To test for changes in these sequence types, the first (less complex) model that did not fit the data was applied. This model included all possible 2-way interactions plus main effects (Lag0 $\times$ Lag1 $+$ Lag0 $\times$ Period $+$ Lag1 $\times$ Period)[9] such that adjusted residuals could be examined for significance (see Figs. 4 and 5). The adjusted residuals represent a standardized effect size and direction of change; they do not indicate an actual difference between two values. Because comparisons were made between only two levels of a factor (Period: pre- and postperturbation), each preperturbation

[9]Lower order factors or interactions (in this case, main effects) are always implied in log-linear analysis and not written conventionally.

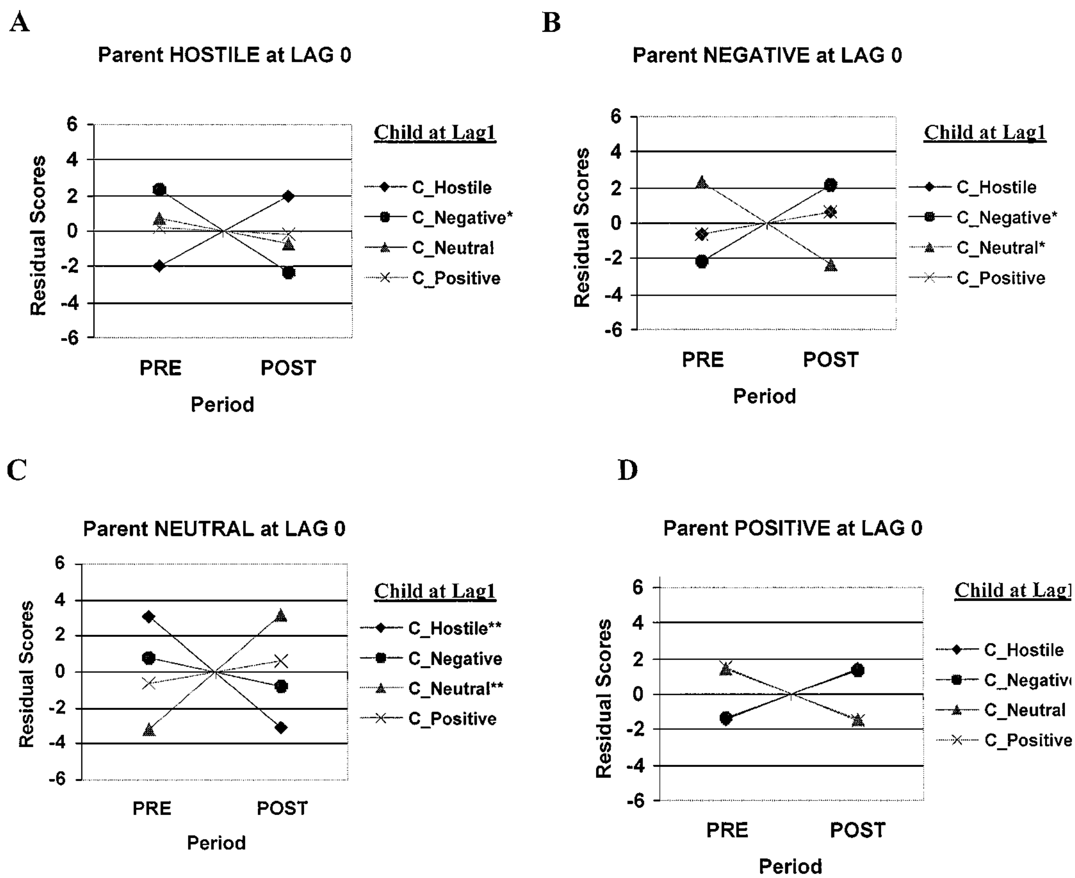

Fig. 5. Adjusted residuals for MIXED dyads when parent's behavior is considered the antecedent and child's behavior is the consequent. Adjusted residuals >|1.96|, |2.58|, and |3.30| are considered statistically significant at the *.05, **.01, and ***.001 level respectively. C_ = parent's behavior; P_ = parent's behavior.

residual necessarily has an exact reciprocal value for postperturbation. Thus, what is important to note first are any residuals that are significant, that is, higher than an absolute value of 1.96 and, second, whether they change from positive to negative (indicating a decrease) or show the opposite pattern.

Panel A in Fig. 4 shows that the decrease (after the perturbation) in the parent's neutral response to the child's hostility is statistically significant, $p < .001$. This result is consistent with the state space grid patterns indicating decreased permissiveness for MIXED dyads in response to the perturbation. Panel A also shows that mutual hostility increases after the perturbation for this group: the increase in parent's hostility in response to child's hostility is statistically significant.

In Panel B, a statistically significant increase in mutual negativity is shown, as expected, but the decrease in parent neutrality was not significant. Panel C shows that the tendency for parent to respond neutrally in kind increases significantly, $p < .001$, whereas her tendency to initiate hostile or negative behaviors decreases. As shown in Panel D, no significant effects were found for changes in the parent's response to child's positivity. Taken together, these results support the impressions obtained from the state space grids: for MIXED dyads, permissiveness decreased and mutual hostility increased after the perturbation.

Adjusted residuals for parent → child sequences are presented in Fig. 5. Panel A shows a trend towards an increase in the child's hostile response to the parent's hostility (the adjusted residual = 1.95), consistent with the observed increase in mutual hostility on the state space grids. Panel B shows a parallel increase in negativity (and a decrease in neutrality) toward the parent's negativity. Similar to the parent at Lag1, Panel C shows that the child's neutral responses to the parent's neutral behaviors increased significantly ($p < .01$) and the child's tendency to initiate hostility decreased significantly ($p < .01$). No significant changes were found in the child's responses to the parent's positive behaviors.

Winnowing Results to Guard Against Type I Error

Taken together, the significant adjusted residuals—when parent or child's behavior is considered the antecedent—were consistent with the state space grid results suggesting that MIXED dyads shifted from a permissive to a mutually hostile pattern. To guard against the probability of Type I error, a winnowing procedure was conducted.[10] The procedure involves changing the observed frequencies in the cells of interest to structural zeros in the database. Then, the same model that was used to obtain the standardized residuals is retested. If the observed frequencies now adequately match the expected frequencies (i.e., if the G^2 is no longer significant), it can be concluded that those cells indeed tapped the important transitions.

Beginning with the table for child at Lag0 and parent at Lag1, the two cells representing the permissive and mutual hostility transitions were declared structurally zero: child hostile → parent neutral; child hostile → parent hostile. Recall that when these cells were included, the "all 2-way" model did not fit the observed data, $G^2 = 22.05$, $df = 8$, $p = .009$. After the two cells were set to zero, results revealed an almost exact match between observed and expected frequencies, $G^2 = 2.50$, $df = 12$, $p = .998$. Thus, the findings strongly suggest that it was the change in these two patterns that accounted for the statistical interaction between dyadic behavior and period (Lag0 × Lag1 × Period).

The same procedure was run with the table representing parent at Lag0 and child at Lag1. This time, the cell that was set to zero was: parent hostile → child hostile, representing the mutual hostility transition. When this cell was set to zero, the model fit, although not very well, $G^2 = 16.12$, $df = 10$, $p = .10$.

DISCUSSION

The main objective of this study was to examine the parent–child processes differentially associated with EXT and MIXED subtypes of aggressive youth. Principles of dynamic systems suggested design strategies that could tap these differences and pointed to analytic techniques that could measure them. The dyads' adjustment to a planned perturbation was expected to distinguish subtypes by shifting behavior to different regions of the state space for each subtype. Statistical analyses were conducted to confirm and extend these observations.

Results from both the state space grids and the log-linear modeling procedures answered our first research question and supported our hypothesis that differences between dyadic subtypes would be found only after interactions were perturbed. Results showed that it was MIXED, and not EXT, dyads who changed their interaction patterns after the perturbation. More specifically, both MIXED and EXT dyads tended toward the permissive region of the state space before the perturbation, but only MIXED dyads shifted to the mutually hostile region afterward. Log-linear results confirmed that the final model for the postperturbation, but not preperturbation, period showed group differences and that only the MIXED group showed dyadic changes from pre- to postperturbation.

The current results add support to the small number of studies which have identified differences between MIXED and EXT children's parent–child interactions (Dadds et al., 1992; Donnenberg & Weisz, 1997; Sanders et al., 1992). However, our findings differ in the content of these differences. Specifically, the studies by Dadds et al. (1992) and Sanders et al. (1992) showed that MIXED dyads were *less* likely to show hostility, and more likely to show elevated levels of depressed affect, compared with EXT dyads. In part, these inconsistencies may be due to sample differences—the previous studies included girls and fathers as well as boys and mothers. Also, the Dadds and Sanders studies were based on observations made in the home during free time and meals, as compared to our laboratory task.

Our findings also contradict those studies which found no differences at all between the two subtypes' family interactions (Capaldi, 1991, 1992; Capaldi & Stoolmiller, 1999). These contradictory findings may be a result of using different coding systems. We did not code for depressed affect (our pilot data suggested a very low base rate for this code). Or it may be that the observational data were analyzed at different levels of specificity (global impressions versus sequential, event-based analysis).

More important than these inconsistencies, however, may be our reliance on DS principles for observing differences as dyadic reorganizations in response to a perturbation. It was only by attempting to change relevant contextual constraints that dyadic subtypes became distinct. Transactional theorists have long emphasized the implications of varying interactional contexts in order to

[10] We needed to by wary of Type I error for two reasons. First, there were numerous comparisons made in the previous analyses. Second, adjusted residuals form an "interrelated web" (Bakeman & Quera, 1995) in that, when some are large, others must necessarily be small. Thus, although we have presented all of them for descriptive purposes, it is not recommended to interpret each of the adjusted residuals individually. Bakeman and colleagues (Bakeman & Gottman, 1997; Bakeman & Quera, 1995) suggest using a "winnowing" procedure to test the importance of theoretically interesting transitions that are associated with significant adjusted residuals.

tap variability in behavioral outcomes (Bronfenbrenner, 1979, 1986; Dumas et al., 2001; Hinde, 1992; Sameroff, 1983; Sroufe, 1989), but this study is the first to empirically apply this insight to the study of aggressive subtypes.

To answer our second research question, the particular content of the changes for each group was identified by first examining the state space grids and then the statistical significance of the adjusted residuals obtained from the log-linear procedures. For EXT dyads, the child hostile → parent neutral sequence was the most probable both pre- and postperturbation, after mutual neutrality, indicating that this group engaged in a permissive pattern throughout the problem-solving session. No changes in dyadic interactions were found in response to the perturbation. These findings are consistent with many studies that have found that permissiveness is a characteristic pattern for externalizing children and parents (e.g., Dumas & LaFreniere, 1993, 1995; Patterson, 1982; Patterson et al., 1992; Snyder et al., 1994; Snyder, Schrepferman, & St. Peter, 1997). The current findings extend this past research by highlighting the stability of this pattern for the EXT subtype in contrast with the unstable patterns found for the MIXED subtype.

As suggested by the state space grids results, MIXED dyads decreased in permissiveness after the perturbation; statistically this was evidenced by the significant decrease in the parent's tendency to respond to the child's hostile behavior with a neutral behavior. However, permissiveness tapped by the parent's neutral response to her child's negativity did not decrease statistically, although results were in the expected direction. MIXED dyads also showed a significant increase in mutual hostility. Studies concerned with examining coercive processes have found this pattern to be common among aggressive dyads (e.g., Patterson, 1982; Patterson, Reid, & Dishion, 1992; Snyder et al., 1994, 1997), but the current findings also suggest that MIXED dyads are more likely to engage in mutually hostile interchanges when there is a sudden emotional urgency for resolution.

According to Dumas and colleagues (e.g., Dumas & LaFreniere, 1993, 1995) the differences between internalizing and externalizing children's family interactions can be summarized as follows: unpredictable, indiscriminately positive parental responses to children's noncompliance lead to the development of childhood aggression, whereas predictably discriminate but intrusive and hostile parental behaviors lead to childhood anxiety. Consistent with these authors' conceptualization, mothers of EXT children remained permissive over time. Mothers of MIXED children also responded indiscriminately (i.e., permissively) toward their children's noncompliance, just like parents of purely aggressive children. However, after the perturbation, these mothers became discriminate and hostile. These findings are also consistent with past research which has shown that harsh and controlling parental behaviors are associated with the development of anxiety problems in children (e.g., Barrett, Rapee, Dadds, & Ryan, 1996; Dadds, Barrett, Rapee, & Ryan, 1996).

In comparison to EXT mothers, MIXED mothers seemed to have a shorter fuse. When MIXED mothers feel an increase in the pressure to control their noncompliant child, they may suddenly retaliate with their own hostility. This retaliation may be experienced as unpredictable by the child. Although the child's behavior may not have escalated, the parent suddenly changed from responding in a passive way to becoming hostile in kind. Why might these mothers react in this way? Given that there is a small but significant genetic influence in the development of anxiety problems (e.g., Rutter et al., 1990), mothers of MIXED children may be clinically anxious themselves. As a result, it may be that the perturbation triggered elevated levels of anxiety for MIXED mothers leading to sudden hostility (Barrett et al., 1996; Dadds et al., 1996). Whatever the underlying cause, MIXED children may feel unable to anticipate their mother's erratic behavior and, thus, they may experience high levels of anxiety during family conflicts. Over time, similarly repeated anxiety-provoking experiences may contribute to the development of serious internalizing symptoms that co-occur with externalizing problems in these children.

The postperturbation interactions of MIXED dyads are also consistent with the "authoritarian" parenting patterns (i.e., harsh, hostile, and lacking in warmth) that have been found to relate to anxiety and aggression in children (Baumrind, 1971; Maccoby & Martin, 1983) and the punitive and belittling parental style related to childhood depression and aggression (Poznanski & Zrull, 1970). Thus, at least when considering parental behavior, the parent–child relations of MIXED children seem to constitute a combination of patterns found in families with single-syndrome children. More importantly, the present findings suggest the conditions under which each pattern might be observed: in less urgent, more relaxed problem-solving periods, MIXED dyads look similar to EXT dyads, but when the emotional pressure is increased, their parent–child interactions become distinct.

It is important to note that it was not the parent's *individual* behaviors that changed after the perturbation for MIXED dyads but the interaction between parent and child behaviors. Although it may be argued that it is theoretically impossible to disentangle a dyadic relationship, it seems important to at least consider the child's responses to his parent as well. From this perspective, results showed a strong trend toward an increase in mutual hostility after the perturbation. But, perhaps more interestingly, there was a decrease in what is usually referred to in the literature as the probability of "child startup" (e.g., Patterson et al., 1992), or the probability of the child initiating a hostile exchange without provocation.

The pattern of adjusted residuals for MIXED dyads seem to point to an increase in contingent (i.e., of like kind) dyadic responding after the perturbation. This was evident not only by the increase in mutual hostility already discussed, but also by the increase in the parent's tendency to respond with negativity toward her child's negativity and neutrally toward his neutral behaviors. In Dumas and colleagues' "balance of power" terms, at the same time as the mother begins to respond in a "tit-for-tat" fashion with her child (after the perturbation), the child is less likely to initiate control efforts. Thus, the dyad as a unit shifted its behavior—this seems to suggest broader systemic changes that are intimately linked to the history of that system. It may be that, for one or both dyad members, the perturbation triggered an urgency to resolve, a sense of "this is for real now." This change in context may have signaled the parent that it is time to reign in the child's controlling behaviors; the child, at the same time, may have been signaled that "mom's real mad, I better cool it." These reciprocal signals may have initiated a feedback process in which both dyad members, monitoring the other's behavior, shifted their own behavior in response. These interpretations are quite speculative; there were no measures of how the perturbation was appraised by either dyad member, nor was this particular pattern of results predicted. But the results do highlight the bidirectionality of parent–child interactions that underpin clinical child outcomes.

Limitations and Future Directions

First, the study is limited due to the small sample size. To be confident in characterizing MIXED and EXT parent–child interactions, replication of the current findings with a larger sample is critical. Second, a nonclinical comparison group was not included in this study. As a result, both permissiveness and mutual hostility are interpreted, at least implicitly, as pathogenic. It may be that the permissive pattern that was evident for both groups preperturbation is also characteristic of normal families and that it is only the postperturbation context that differentiates distressed families. A comparison group would be helpful to include in future research to clarify how skillful parent–child pairs interact in problem-solving interactions both before and after a stressful perturbation.

Third, the study focused on boys' interactions with their mothers. Gender differences could not be examined because there were very few girls referred to the treatment programs from which participants were recruited. As a result, the interpretations of the data cannot be generalized to girls with externalizing problems. Fathers were also not included; the findings speak only to patterns that may be typical for mothers with EXT and MIXED boys.

A further limitation to the study is the lack of information collected about mothers in the sample. There is a well-established connection between parental psychopathology, particularly depression, and child psychopathology (e.g., Cummings & Davies, 1992); thus, to get a more complete picture of MIXED and EXT parent–child interactions, it seems important to understand the parent's symptomatology as well as the child's. A final limitation concerns the lack of direct evidence regarding the nature of the perturbation. Results from this study suggest that something about the knock on the door and the experimenter's instructions regarding that knock prompted MIXED dyads to shift interaction patterns. Yet it remains unclear how dyads experienced the knock. It seems important in future work to directly assess participants' emotional reactions and appraisals.

Implications

Despite the limitations, the results highlight the importance of recognizing the heterogeneity among aggressive youth and their families. This heterogeneity has long been recognized theoretically, but empirical investigations of aggressive parent–child relations rarely distinguish subgroups. For example, much of the research on aggressive family processes has built on the findings of Patterson and his colleagues (Patterson, 1982; Patterson et al., 1992) which has focused on coercive, hostile interactions. But most of these studies did not measure children's concurrent levels of internalizing problems. Thus, it is unclear the extent to which those past findings reflect the patterns of MIXED children. This study examined differences in subtypes' dyadic relations and the results suggest that, indeed, the interactions of MIXED and EXT children are distinct. These results provide further evidence for the validity of subtyping aggressive children on the basis of whether or not they also exhibit co-occurring internalizing symptoms.

A second implication of this study concerns the ways in which a DS approach allows researchers to examine structural differences in groups that were previously believed to be homogeneous. Without perturbing the dyadic system, and examining behavior on a state space of possible patterns, subtypes' parent–child interactions would have been indistinguishable. This general DS principle may be applicable to a variety of phenomena in developmental psychopathology including variability in the real-time unfolding of attachment styles and subtypes of internalizing children.

Finally, although DS methods are only just beginning to be developed, this study suggests the utility of using a variety of complementary analytic strategies. By combining the case-sensitive, exploratory state space grid method with a more established group-based analysis, our analytic strategy assured that the results were not only significant at the group level, but reflected typical parent–child patterns for most dyads.

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