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Adolescent Friendship as a Dynamic System: Entropy and Deviance in the Etiology and Course of Male Antisocial Behavior

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A dynamic systems framework was applied to understand the influence of friendship on antisocial behavior from childhood (age 9–10) through adulthood (age 24–25) for Oregon Youth Study males ($N = 206$). Boys were videotaped interacting with a friend at ages 14, 16, and 18, and deviant content and interpersonal processes were independently coded. Conditional dyadic interpersonal processes were studied as a communication system and summarized by an index of information entropy (F. Attneave, 1959). High entropy scores represent disorganized, unpredictable patterns of interaction, whereas low entropy scores reflect an organized dialogue. Conversations of early-onset antisocial boys and their best friends were less organized and included more deviant content than those of well-adjusted controls. Prediction analyses, however, revealed an interaction between entropy and deviant talk. Consistent with expectation, males with well-organized interactions (i.e., low entropy) but elevated levels of deviant content were most likely to continue antisocial behavior into adulthood. Findings suggest that individual risk for maladaptation may be amplified by early adolescent friendship dynamics organized around deviance.

KEY WORDS: antisocial behavior; peer relations; dyadic interaction; friendship.

Considerable evidence and theoretical support exist for the idea that adolescent friendships have a unique and significant impact on long-term patterns of social development (Hartup, 1983; Piaget, 1954; Sullivan, 1953). Indeed, the last 20 years are marked by a growing literature on the positive effects of friends (e.g., Berndt, 1996; Bukowski & Hoza, 1989; Cauce, 1986; Furman, 1996; Newcomb & Brady, 1982; Parker & Asher, 1993; Youniss, 1983). Unfortunately, there is also a dark side to friendships, contributing, sometimes dramatically, to social maladaptations and problem behavior (Hartup, 1996).

The study of negative peer influence is especially relevant to understanding the development and course of antisocial behavior (Dishion, French, & Patterson, 1995). Psychologists (e.g., Quay, 1993), psychiatrists (e.g., Robins, 1966), and sociologists (Burgess & Akers, 1966; Elliott, Huizinga, & Ageton, 1985; Giordano, Cernkovich, & Pugh, 1986; Gold, 1970; Short & Strodbeck, 1965) have placed peer influence as central to classification, etiology, and the course of deviance. Healy (1927), one of the earliest psychological scholars of adolescent deviance, observed:

> . . . bad companions play an immense part in the production of criminalism. To be sure there are quite solitary individuals who have developed an anti-social grudge, or who have deliberately entered upon a professional criminalistic career, but the majority work up their impulses gregariously. Bad companions may be considered as part of the psychical environment, and may exert influence under many varying conditions. (p. 293)

Over 75 years later, we continue to work on understanding the dynamics through which "bad companions" contribute to the motivation to commit deviant acts (Bagwell, Newcomb, & Bukowski, 1998; Dishion, Spracklen, Andrews, & Patterson, 1996; Fergusson & Horwood, 1999; Vitaro, Gendreau, Tremblay, & Oligny, 1998). Not only is the understanding of the dynamic of negative peer influence important for designing realistic

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intervention strategies that reduce problem behavior, but also for clarifying the role of friendships in normative development (Cicchetti & Toth, 1992).

The study of influence in close relationships is as complicated as it is informative. Much of the work on influence has been generated from a learning paradigm, in which there is a focus on studying and identifying contingent action–reaction patterns. For example, we tested the proposition that friends' contingent, positive reactions to deviant talk influence the development of adolescent problem behavior (Dishion et al., 1996). Formal testing of this idea requires the collection of direct observations of friendship interactions, such as deviant talk and laughter, that capture antecedents and consequences. Contingencies between two proximal events (i.e., lag 1 contingencies: t_n and t_{n+1}) can be quantified by a Z score (Bakeman & Gottman, 1986; Bakeman & Quera, 1995; Gottman & Roy, 1990; Sackett, 1979). When two events reliably covary in time, the Z score index is above 1.96.

Using this approach, we found support for the hypothesis that friends mutually influence one another through laughter contingent upon deviant talk. We also discovered that not only did antisocial boys respond more positively to deviant talk, they also *did not reinforce* normative talk. In general, adolescents tended to match their level of deviant talk to the relative rate of reinforcement, a principle referred to as *matching law* (for a review, see McDowell, 1988). The relative rate of reinforcement can only be understood by studying dyadic reactions to both deviant and normative talk.

Despite the promise of the sequential approach for understanding friendship influence, the quantitative framework of contingency analysis has its limitations. Bakeman and Quera (1995) proposed several limitations to the use of Z scores in the analysis of interaction sequences. Both the manner in which codes are defined (on a dyadic or individual level) and the number of events within a sequence affect the magnitude of the Z score.

Another approach to studying friendship influence is to think of the relationships as a *dynamic system* (Abraham, Abraham, Shaw, & Garfinkel, 1990; Dumas, Lemay, & Dauwalder, 2001; Lewis, 2000). In contrast to sequential analyses, a dynamic approach is not concerned just with contingencies among proximal events, but also considers the overall temporal organization of the dyadic exchange. In this sense, a dynamic-systems analysis is a general methodological framework for studying relationship process (Granic, Hollenstein, Dishion, & Patterson, 2003). A key strategy within this approach for studying the organization of relationship exchanges is the use of a *state-space grid* (Duncan, 1991; Lewis, 2000). Figure 1(a) and (b) are the interaction state-space grids for two

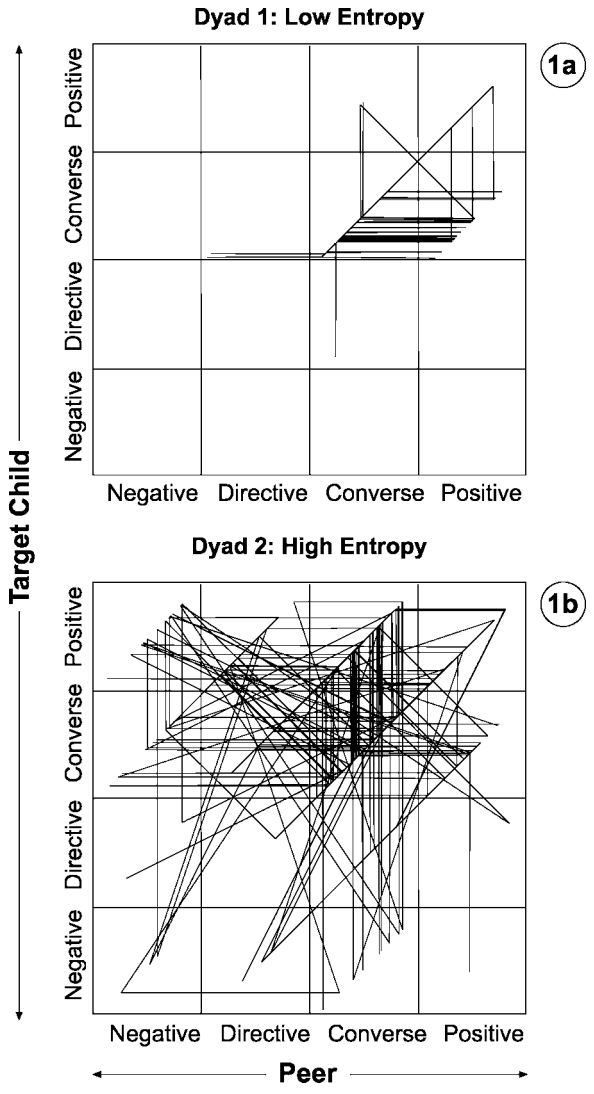

Fig. 1. (a) and (b) A state-space grid: High and low entropy friendship dyads.

friendship dyads in the Oregon Youth Study (OYS). These grids display the interactions of each friendship dyad over the entire observation session. In our previous research (Dishion, Andrews, & Crosby, 1995), the interpersonal dynamics of friendship interaction were coded as Positive Engagement (compliment, praise), Directives (command, requests), Negative Engagement (criticism, blame), and Converse (calm talk, discussions). These categories are used in the state-space grids shown in Fig. 1(a) and (b).

A visual inspection of these two friendship interactions using state-space grids reveals many possible comparisons of possible theoretical interest. One obvious difference between these two friendship interactions is the level of order and organization in the dyadic exchange.

Even though both friendship interactions have approximately the same number of events, one dyad restricts interactions to one area of the state-space grid, while the other appears more disorganized and complex.

Information theory provided an important quantitative and conceptual framework for defining and understanding this particular dynamic structure (Attneave, 1959; Campbell, 1982; Krippendorff, 1986). Using this framework, transitions in events are conceptualized as units of information. Information systems can range between being organized and predictable (Fig. 1(a)), or complex and uncertain (Fig. 1(b)).

The general idea is that less information is needed to predict the reactions from actions in a low entropy dyad [Fig. 1(a)], compared to a high entropy dyad [Fig. 1(b)]. Entropy (H) is computed simply by considering the distribution of conditional probabilities within an action–reaction transition matrix. Therefore, a transition matrix low in entropy (H) would have many zero cells in a state-space grid (see Fig. 1(a)) and one or two transition cells that were heavily used by a dyad. Conversely, a high entropy transition matrix would be one in which all conditional cells were equiprobable (see Fig. 1(b)).

Note that a low entropy dyadic exchange does not tell us anything about the content of the exchange, just the dynamic interpersonal structure. One of the most common low entropy patterns is one in which both adolescents engage in extended discussions, represented by the Converse–Converse area of the grid. Friends who have long, uninterrupted conversations are those most likely to be quantified as a low entropy exchange. However, we have no idea what the boys in such a friendship are talking about. To understand negative peer influence, it is important to study the content of the interaction, and more importantly, the interplay between the content and the dynamic structure of the friendship interaction.

An important methodological detail is worth noting at this juncture. In order to study the interface between the structural dynamics and the content of a friendship interaction, it is important to code for these dimensions independently. If the same coding system is used to define both, there is a numerical confound. For example, it would be true by definition that dyads who engage in high levels of deviant talk would be those that are low in entropy, if entropy was quantified using a coding system for deviant talk. In this study, we consider the structural dynamics of the interpersonal process in relation to the content of the boys' interactions, each measured by independent coding systems.

How might the computation of entropy on adolescent friendship interactions further our understanding of adolescent friendships on antisocial behavior? Some expectations can be derived from the literature on the development of antisocial behavior, deviant peer relationships, and peer relationships, in general.

Several researchers propose that antisocial children exhibit *arrested socialization* (Coie, Dodge, Terry, & Wright, 1991; Dodge & Coie, 1987; Patterson, 1982; Patterson, Reid, & Dishion, 1992), reflected in generalized low social skills and competence (Dishion, Loeber, Stouthamer-Loeber, & Patterson, 1984). Interpersonally, such youth tend to misread cues, overreact to ambiguous provocations, and disrupt organized peer activities. Moreover, this level of dysregulation and social skill deficits may be most pronounced with youth who initiate their antisocial behavior early in development (Moffitt, 1993; Patterson, 1993). Dysregulation also may be amplified when considering the likelihood that antisocial youth select other antisocial youth as friends (Cairns, Leung, Buchanan, & Cairns, 1996). We would expect, in general, that boys who initiate their antisocial trajectories early, and persist through adolescence, may show more disorganized (high entropy) friendship interactions than boys who are not antisocial.

It is also safe to assume, based on previous research (e.g., Dishion et al., 1996), that the content of the friendships of the antisocial adolescents will be rated as more deviant than that of their normal counterparts. What is more interesting to consider, however, is the interrelation between the entropy of the friendship interaction and the deviance of the content.

What dynamics contribute most to *influence* within adolescent friendships? In our previous work, we found that the matching law was a convenient index for describing the reinforcement dynamic associated with high levels of deviant talk and the influence of the friendship on subsequent deviance. Stepping back to think about influence from a dynamic systems framework, friendships organized and focused on deviance are expected to be more influential, as they reflect a dyadic interest in deviant topics. It could be said that the friends get "stuck" talking about deviant topics.

In a chaotic system, a cyclical attractor (see Abraham et al., 1990) describes a dynamic of two boys getting stuck talking about deviance. Using our interpersonal process coding system (Peer Process Code; Dishion et al., 1989), the boys would look very much like the low entropy dyad in Fig. 1(a), stuck in the Converse–Converse area of the state-space grid, with occasional laughter and positive affect to punctuate and communicate approval of deviance. Contingent reaction patterns that maintain the conversation exchange would be difficult to reliably discern, using sequential analyses because there would be few interruptions to these extended discussions. However,

using a dynamic systems approach, we would be able to test the prediction that low entropy (well organized) deviant discussions within friendships are the most prognostic of long-term trends of antisocial behavior, because such friendship dynamics reflect mutual interest and support for problem behavior.

In summary, we use the longitudinal data of the OYS sample to address several hypotheses:

A. The dyadic interactions of boys with their friends at ages 14, 16, and 18 will show a developmental trend of maturation toward increased organization, therefore decreasing levels of entropy.
B. Entropy in friendship interactions will differentiate longitudinally two distinct developmental trajectories of males (early starting and persisting antisocial versus persisting well-adjusted). Because of arrested socialization, the general tendency will be for early starting antisocial boys to show higher levels of entropy (more disorganized interactions) than boys who are defined as well-adjusted.
C. Deviant talk in the friendship interactions will differentiate longitudinally two distinct developmental trajectories of males (early starting and persisting antisocial versus persistently well-adjusted). Specifically, early-onset boys will show higher levels of deviant talk throughout adolescence than well-adjusted boys.
D. Friendships organized around deviance will predict adult antisocial behavior, over and above the main effects of adolescent antisocial behavior, deviant talk, and entropy. Therefore, a statistically reliable interaction will occur between entropy and deviance in predicting antisocial behavior into adulthood.

Below, we describe the details of the OYS procedures, measurement methods, and analytic strategies to test these hypotheses.

METHODS

Participants

This study used data from the 206 boys involved in the OYS, who were recruited from fourth grade classes at a successful recruitment rate of 74.4%. The boys, between age 9 and 10 when data collection began (1983–1984 school year), attended schools in a high-crime area of a medium-sized city in the Pacific Northwest. Consistent with the demographics of the region, participating families were predominantly European American and of lower socioeconomic status than the national average. More than 20% of parents were unemployed and on some form of welfare or financial assistance during the first year of the study. Initially, 42% of the families were intact (two biological parents), 32% had a single parent, and 26% were stepfamilies (Patterson et al., 1992). Data used in this study were collected between 1983 and 1998, when the boys were between the ages of 10 and 24. Retention during that period was 96%.

Interviews and Questionnaires

Throughout the course of the study, the OYS males were assessed annually using parent and child interviews and questionnaires completed by the youth, parents, peers, and teachers (through high school) at the time of the interview. The questionnaire and interview data used in this study are described in detail below.

Videotaped Observations

Boys participated in peer interaction tasks at ages 14, 16, and 18. During the parent and child interview portion of these assessments, the boys and parents independently identified the three male friends with whom the boys spent the most time (rank-ordered). The male friend identified by both the parent and study boy as being the most frequent companion was identified for recruitment into the friendship study. At ages 14, 16, and 18, the recruitment rate averaged 92% across the three assessment waves (91%, age 14; 88%, age 16; 86%, age 18). For all recruited friends, a home visit was made to discuss the study and to obtain informed consent from each friend and his parents.

At each time point, the boys brought a friend to the lab and they were videotaped interacting across a 25-min session. During that time, the boys were instructed to plan an activity together and discuss four problems (two per boy) they were having with parents and peers. The problem-solving tasks were counterbalanced.

As discussed above, the videotapes were coded by two groups of independent coding teams, focusing on different aspects of the interaction. The Peer Process Code (PPC) focused on the interpersonal process of the friendship interaction and the Topic Code focused on the deviance of the discussion topic. Both coding systems relied on coded speakership and used an event recorder to obtain the sequencing and duration of the relationship interaction.

Peer Process Code

The PPC, developed for the purpose of coding the dyadic friendship interactions in this study (see Dishion et al., 1995), focused on assessing the interpersonal process of a close relationship. Codes were systematically created to represent a 3-by-3 interpersonal behavior grid, which defined behaviors as verbal, nonverbal, and physical (three dimensions of topography), and as interpersonally positive, neutral, or negative. The positive or negative impact dimension was based on a series of studies that assessed the subjective ratings of behaviors coded within similar systems (see Hoffman, Fagot, Reid, & Patterson, 1987).

Behaviors were entered with an event recorder, with each entry defining the initiator (one digit), the content (two digits), the recipient (one digit), and the affective valence. The latter was recorded by entering one digit (among six), indicating anger-hostility (two levels), depression, neutral, and positive affect (two levels). The 24 codes used in this system were clustered into four a priori summary scores: Negative Engagement, Directives, Positive Engagement, and Converse.

Negative Engagement represented all codes presumed to have a negative interpersonal impact (e.g., criticisms, verbal attacks, name calling, coercive threats), as well as any neutral or positive content codes recorded in negative affect. Directive was indicated by two content codes describing the adolescents' attempt to direct or guide the behavior of his friend. Positive Engagement included all positive content codes (compliments, positive nonverbal gestures, endearments), as well as neutral codes recorded in positive affect. Finally, Converse included only one code (talk) recorded in neutral valence. Much of the interaction in both families and friendships is coded talk, which motivated creation of the Topic Code to describe the content of the discourse.

Topic Code

The Topic Code was designed to capture variability in the boys' discussion topics (Poe, Dishion, Griesler, & Andrews, 1990). In contrast to the PPC, the Topic Code measures the extent to which antisocial boys selectively reinforced deviant talk.

To assess deviant talk, we took a broadband approach to topic classification: If two coders agreed that a discussion was in violation of conventional norms, it was coded as rule-breaking talk, which consisted of any reference to violations of legal or conventional norms, any inappropriate behavior during the taped interaction, and any activities violating the instructions given for the task. All other talk was coded as normative: If two boys talked about the dangers of drug use, they would be coded as normative talk. In contrast, if the two boys discussed their own drug use, it would be coded rule-breaking talk. Because of the contextual nature of such topics, we found it necessary to simplify the coding of discussion topics by having only two possible topics.

Perusal of the videotapes indicated that laughter was pervasive in almost all videotaped interactions. Occasionally, the boys would pause in reaction to something that was said. Our informal perusal of the videotapes suggested that these two reactions were important determinants of the direction the discussion would take. Our two reaction codes were either *laugh* or *pause*.

For this study, we examined the average duration of rule-breaking talk and combined it with coder impression of drug use and antisocial norms to form a deviant friendship process construct described below.

Coder Impression Scales

Following the PPC coding, observers completed an inventory assessing their global impressions of the friendship interaction from the 25-min videotaped interaction. As in previous research, two scales from this inventory were used. Drug talk was derived from coder responses to 12 questions to determine if the child or his peer referred to use of six specific substances (alcohol, tobacco, marijuana, cocaine, hallucinogens, methamphetamine) during the peer interaction task. The six questions for each child were averaged, then the mean of the two boys' scores was taken. Correlations between boy and peer drug talk ranged from .87 to .97. The antisocial behavior indicator represented the mean of coder responses to two questions regarding the boy and his friend, including how much the two engaged in antisocial behavior and how much the peer encouraged antisocial behavior from the target boy during the interaction.

Two scores were computed to describe the friendship interactions at each of the three time points (ages 14, 16, 18). The deviant friendship process score was based on the coding from the Topic Code, and coder impressions from the PPC coding. The entropy score was based on a conditional transition matrix ($T_0 - T_1$) using the computational formula of Attneave (1959) within the framework of information theory.

Deviant Friendship Process

The deviant friendship process construct consisted of three indicators: duration of rule-breaking talk, coder

impressions of drug talk. All indicators except duration of rule-breaking talk were on the same scale, so we multiplied rule-breaking talk by 0.003 and averaged the three indicators to create the composite score. The construct was internally consistent with a standardized alpha of .70 at age 14, .77 at age 16, and .71 at age 18.

Entropy

In the current study, entropy was calculated for the peer interactions using the PPC clusters (Negative Engagement, Directives, Converse, Positive Engagement). As applied in information theory (Attneave, 1959; Shannon & Weaver, 1949), entropy refers to the amount of information in a message as measured by the logarithm of the number of possible equivalent messages, $H = \sum(p_{ij} \times \ln[1/p_{ij}])$. In applying this formula to our PPC data, p refers to the distribution of conditional probabilities in a lag 1 transition matrix; p_{ij} refers to the conditional probability that a behavior was followed by another behavior in the state transition matrix. In general, if several of the conditional p values approach zero and others are high in the state transition matrix, then entropy will be quite low. If the conditional p values are distributed equally across the matrix, entropy will be high. In general, in the latter case, the interaction is less predictable since it would be difficult to predict one friend's behavior from the other's in a second-by-second analysis. To yield the state-space transition diagrams from which the entropy scores were computed, three data manipulations were required. The first involved recoding the stream of behavior into the summary clusters described above: Positive Engagement, Negative Engagement, Directives, and Converse. Second, when multiple behaviors were entered contiguously for either the boy or peer, we selected one of the behaviors according to priorities: Negative Engagement, Directives, Positive Engagement, and Converse. For example, consider the following stream of behavior with the study boy coded in multiple behaviors at Time 1: Boy Converse, Boy Negative Engagement, Peer Negative Engagement, and Boy Converse.

This stream of behavior was recoded to Boy Negative Engagement (Time 1), Peer Negative Engagement (Time 2), and Boy Converse (Time 3). The rationale for this approach to prioritizing is based on multiple studies indicating the interpersonal salience of negative and positive interpersonal events in the influence process and relationship satisfaction (Gottman, 1979, 1998; Hoffman et al., 1987; Snyder, Edwards, McGraw, Kilgore, & Holton, 1994).

Third, we computed the transition matrix by counting the occurrence of each possible transition pair, divided by the total number of antecedents, yielding a matrix of conditional probabilities. Using the matrix of conditional probabilities, we computed the entropy index to represent the overall level of predictability between all possible antecedent and consequence pairs.

Reliability

Reliability was assessed by randomly selecting a subset of peer interactions for observers to code independently. Because we used videotapes, observers were unaware of which session was being used for reliability. Moreover, we randomly assigned observers as the calibrator and reliability when computing percent agreement and kappa.

Reliability on the code clusters used in the state-space grids was high and is summarized in Table I. Also included are the correlations between two observers on

Table I. Summary of Interrater Reliabilities for Peer Process Code Clusters, Average Duration Rule-Break Talk, and Coder Impressions

	Age 14		Age 16		Age 18	
Indicator (n)	K	Agree (%)	K	Agree (%)	K	Agree (%)
PPC[a] clusters (across codes)	.68	82	.75	88	.77	92
Negative engage	.64	53	.69	57	.69	56
Positive engage	.78	79	.82	78	.84	78
Converse	.76	87	.81	95	.83	96
Directives	.70	64	.71	61	.76	68
Other	.62	50	.69	55	.66	52
Topic Code (across codes)	.77	89	.74	91	.72	87
Duration rule-break	.77	76	.75	70	.74	71
Coder impressions		93		92		93

[a]PPC = Peer Process Code.

the coder impression scores and the average duration of rule-breaking talk. Reliability of the entropy scores, defined as the interrater correlation between entropy scores calculated from individual raters, also was high (age 14, $r = .77, n = 32$; age 16, $r = .75, n = 24$; age 18, $r = .91$, $n = 27$).

Antisocial Construct

A multiagent measure of antisocial behavior was created using techniques described by Capaldi and Patterson (1987) and Patterson et al. (1992). The construct was scored at ages 9–18 using child-, parent-, and teacher-report data. The antisocial construct comprised four indicators (two parent reports, teacher report, and a child phone interview). Each indicator was internally consistent ($\alpha > .60$) and loaded highly (above .30) on the antisocial construct. The indicators were standardized and averaged to create the antisocial construct, which showed high reliability at all age points (age 10, $\alpha = .70$; age 12, $\alpha = .73$; age 14, $\alpha = .67$; age 16, $\alpha = .74$; age 18, $\alpha = .55$). For more information on this construct, see Capaldi and Patterson (1989).

Developmental Trajectory Groups

In order to investigate the role of entropy in deviant and normal peer interactions, two groups (one antisocial, one well-adjusted) were compared. The antisocial group was defined as the sample of boys who had been arrested at least once by the age of 14 and had more than two arrests as juveniles. The well-adjusted group had not been arrested even once as juveniles or adults and scored below the mean for the full sample on the antisocial behavior construct (described above) at every assessment wave between ages 10 and 18. The groups were evenly distributed ($n = 39$, antisocial group; $n = 33$, well-adjusted group).

Adult Antisocial Behavior

Parent, interviewer, and child reports were utilized to create a multiagent construct of the OYS boys' young adult antisocial behavior. The construct represents the average of standardized scores from the Child Behavior Checklist–Parent Version (PCBC; Achenbach, 1991) externalizing subscale, the Elliott (1983) Self-report Inventory, and three interviewer impression items. The parent scale yielded an alpha of .91 (only one parent reported per child) and the interviewer impressions yielded an alpha of .72. The self-reported delinquency measure included the participants' reports of the actual number of times that they committed an illegal act. Since many of the acts are rather serious (e.g., rape), and others are less so (e.g. petty theft), two barriers computed internal consistency: (a) there is no common metric, as frequencies vary widely by the type of behavior; b) there are many zeros. The three antisocial scores correlated moderately, yielding a standardized alpha of .46. Because of the importance of using multiple respondents and methods to build constructs, all three scales were retained.

Analyses

Analyses were run on both the full sample and the subsample of antisocial and well-adjusted boys. First, we compared the two subsample groups on entropy, deviant friendship process, and adult antisocial behavior. To investigate the role of deviant friendship process (the content of an interaction) and entropy (the structure of the interaction) in the development of antisocial behavior, hierarchical multiple regressions were computed that predicted adult antisocial behavior from entropy, deviant peer process, and the interaction term, controlling for antisocial behavior in adolescence. The full sample of OYS males was used for the regression analyses, repeated for friendship assessments at ages 14, 16, and 18.

RESULTS

Descriptive Analyses

To provide a description of the friendship characteristic of the boys from early to late adolescence, their responses to two questions were analyzed: "How long have you known this friend?" and, "How much time do you spend together on average every week?" The reports on these descriptive indices are summarized in Table II.

Inspection of Table II reveals that, on average, the friends included in the videotaped assessment had known each other for 4 years. In addition, boys spent an average of 17 hr with these friends at age 14, 17 hr at age 16, and 19 hr at age 18 during the week.

Differences existed between antisocial and well-adjusted boys, as might be expected. Although they did not differ at the age 14 assessment, by ages 16 and 18, boys in the well-adjusted group had known their friends significantly longer (6 years, 5 months) than the boys in the antisocial group (4 years, 5 months), $F(1, 61) = 5.04$, $p < .05$, $\eta^2 = .08$, and $F(1, 62) = 3.73$, $p < .06$, $\eta^2 = .06$, respectively. Antisocial boys spent considerably *more*

Table II. Means on Friendship Characteristics for Well-Adjusted and Antisocial Boys

	Well-adjusted		Antisocial	
	Mean	*SD*	Mean	*SD*
Age 14	$n = 32$		$n = 35$	
Friendship duration (months)	50.00	42.87	50.43	51.98
Time spent together (hours/week)	14.34	18.47	22.06†	17.36
Age 16	$n = 32$		$n = 32$	
Friendship duration (months)	59.03	46.24	36.65*	31.26
Time spent together (hours/week)	12.87	18.37	21.84†	23.17
Age 18	$n = 29$		$n = 35$	
Friendship duration (months)	77.24	47.63	53.37†	50.51
Time spent together (hours/week)	10.76	8.08	34.17**	32.03

Note. Levels of significance are based on univariate ANOVAs comparing groups at each time point.
$^{\dagger}p < .10$. $^{*}p < .05$. $^{**}p < .01$.

time with their friends each week (22 hr at ages 14 and 16, 34 hr at age 18) than well-adjusted boys (14 hr at age 14, 13 hr at age 16, and 11 hr at age 18), $F(1, 65) = 3.11$, $p < .09$, $\eta^2 = .05$, $F(1, 62) = 2.94$, $p < .10$, $\eta^2 = .05$, $F(1, 62) = 14.69$, $p < .001$, $\eta^2 = .19$, respectively. In contrast to the early-onset antisocial group, well-adjusted boys actually spent less time with friends as they got older.

Friendship Dynamics

The first hypothesis focused on developmental change in organization of the friendship interactions over the course of adolescence. The hypothesis proposed a developmental decrease in entropy from ages 14 to 18. This hypothesis was strongly supported by a 2 (group) × 3 (time) repeated-measures analysis of variance. A main effect of time showed a significant linear decrease in entropy across the three assessments for both groups of boys, $F(1, 53) = 43.35$, $p < .001$, $\eta^2 = .45$ (see Fig. 2). As the boys got older, the friendship dynamics became more predictable and organized.

However, differences between the two groups over the course of adolescence also were observed. The analysis of variance found that the two groups differed significantly on the entropy of their interactions across the three assessments, $F(1, 53) = 4.11$, $p < .05$, $\eta^2 = .07$. Antisocial boys consistently scored higher on entropy than well-adjusted boys, suggesting that the interactions of antisocial boys and their best friends were less organized and predictable.

In light of previous research, it is not surprising that both groups also differed significantly on the deviant friendship process composite across assessments, $F(1, 54) = 62.53$, $p < .001$, $\eta^2 = .54$. Antisocial boys' were coded more often in rule-breaking talk and rated by coders as deviant, than were well-adjusted boys. This measure of conversation content did not decrease across time, but showed a marginally significant interaction between the quadratic component of time and group, $F(1, 54) = 3.60$, $p < .10$, $\eta^2 = .06$. Antisocial boys increased their deviant friendship process slightly at age 16, whereas well-adjusted boys did the opposite (see Fig. 3).

To test whether the trajectory differences between groups carry over into adulthood, a one-way ANOVA was used to compare members of the antisocial and well-adjusted groups on adult antisocial behavior. As anticipated, the two groups differed significantly, $F(1, 70) = 19.86$, $p < .001$, $\eta^2 = .22$, with antisocial boys scoring higher ($M = 0.27$) than well-adjusted boys ($M = -0.37$).

Next, we conducted a hierarchical regression on the full OYS sample to determine if adult antisocial behavior

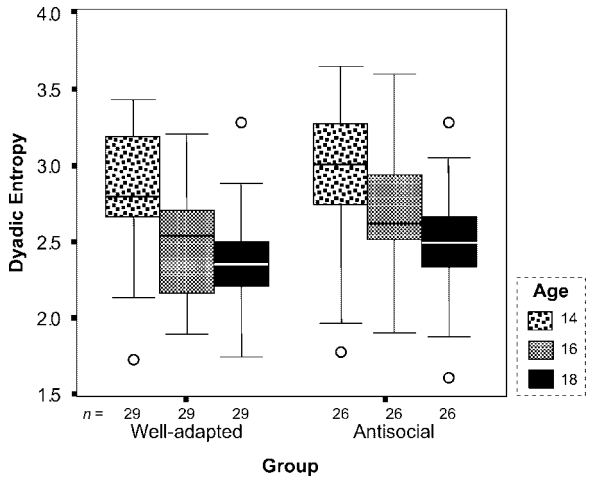

Fig. 2. Entropy of antisocial and well-adjusted boys' conversations at ages 14, 16, and 18.

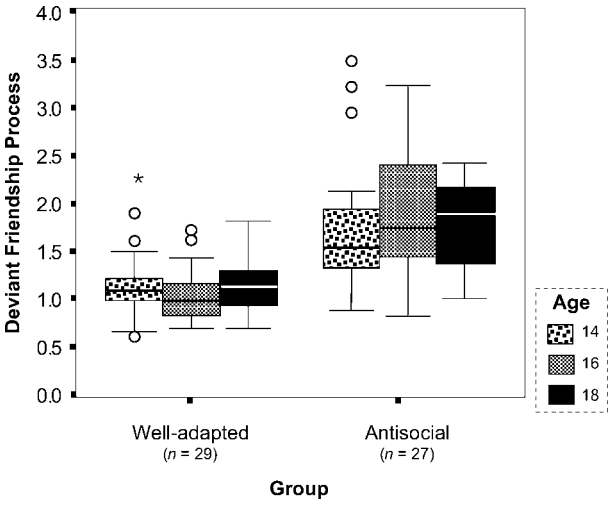

Fig. 3. Antisocial and well-adjusted boys' deviant friendship process at ages 14, 16, and 18.

was predicted by (a) entropy, (b) deviant friendship process, or (c) the interaction between the two (entered into the regression in that order, after the age 14 antisocial behavior construct). We entered entropy before deviant friendship process because we were interested in the variance accounted for by entropy on its own. These analyses are summarized in Table III, which shows that the hypothesis of an interaction between entropy and deviant friendship process was supported only at age 14. Although entropy and deviant friendship process at age 14 were not predictive when entered into the model following age 14 antisocial behavior, the interaction of entropy and deviant friendship process (measured by standardizing the two terms and multiplying them together) at age 14 significantly increased the predictive power of the model (see Table III).

In order to understand the interaction between age 14 entropy and deviant friendship process, we employed Aiken and West's (1991) procedure, plotting entropy's relationship with adult antisocial behavior at different levels of deviant friendship process. Using the unstandardized regression equation, $-.37 + .22$(age 14 antisocial behavior) $+ .01$(age 14 entropy) $+ .27$(age 14 DFP) $- .15$(Zentropy $\times$ ZDFP) = age 24 antisocial behavior, we set age 14 antisocial behavior to 0 (its mean) and calculated predicted adult antisocial behavior for high and low entropy at three levels of deviant friendship process. High age 14 entropy predicted average adult antisocial behavior, regardless of boys' level of engagement in deviant friendship process. However, when entropy was low (indicating highly structured conversations), high deviant friendship process predicted high adult antisocial behavior and low deviant friendship process predicted low adult antisocial behavior (see Fig. 4).

DISCUSSION

Examination of the structure and content of interpersonal dynamics of male adolescents and their friends addresses both theoretical and methodological issues related to studying relationship dynamics. Regarding theory, these data address an old paradox often faced when reading the literature on adolescent conduct problems and

Table III. Summary of Hierarchical Regression Analysis: Antisocial Behavior and Peer Process Variables Predicting Adult Antisocial Behavior

	Standardized βs		
Variable	Age 14 ($n = 188$)	Age 16 ($n = 182$)	Age 18 ($n = 177$)
Step 1			
Antisocial behavior	.31**	.43**	.39**
Step 2			
Antisocial behavior	.30**	.43**	.38**
Conversation entropy	.08	.03	.07
Step 3			
Antisocial behavior	.24**	.36**	.26**
Conversation entropy	.06	−.01	.05
Deviant friendship process	.11	.14	.22**
Step 4			
Antisocial behavior	.24**	.35**	.26**
Conversation entropy	.01	.01	.05
Deviant friendship process	.17*	.11	.22**
Entropy-by-deviant peer process	−.19**	.08	−.02

*$p < .05$. **$p < .01$.

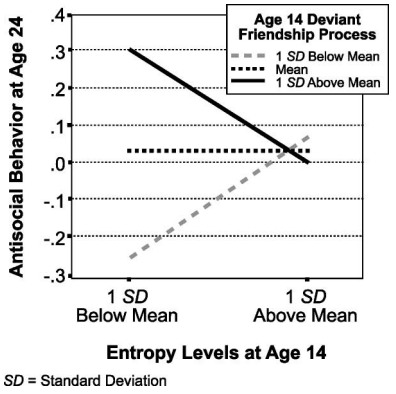

Fig. 4. Deviant friendship process-by-entropy interaction at age 14.

delinquency: Both social skill deficits and association with deviant friends are prognostic of higher rates of adolescent problem behavior.

In the present study, we found that antisocial males were more disorganized (higher entropy) in their friendship interactions. However, entropy did not independently predict continuance of antisocial behavior into adulthood. In fact, levels of entropy decreased for both antisocial and well-adjusted males over the course of adolescence, and friendship interactions became more organized with maturation. In this sense, the antisocial boys could be seen as "arrested" in their social development on this indicator of interpersonal dynamics. These findings are consistent with a developmental perspective on antisocial behavior (see Coie & Dodge, 1988; Dodge & Coie, 1987; Patterson, 1982, 1993; Patterson et al., 1992; Tremblay, 2000).

However, *some* antisocial boys were organized quite well in their friendship interactions. In fact, if they were both organized (low entropy) and engaged in high levels of deviant talk, their prognosis for continuing antisocial behavior into adulthood was particularly poor. We speculate that for some youth, deviance is the venue in which boys catch up with respect to their peer relationships and social skills. Poulin and Boivin (2000) suggest that growth in proactive aggression begins around 10–11 years of age, and that these behaviors are tightly linked to the emergence of a deviant peer group. Perhaps a culture of deviance emerges in middle childhood and is refined and amplified during adolescence. Quay (1993) proposed the distinction between undersocialized and socialized conduct disorder, which once was incorporated in the *Diagnostic* and *Statistical Manual-III* classification of conduct disorder. These data suggest merit in considering a youth's connection to a peer group when evaluating a youth's risk for antisocial behavior and designing intervention strategies.

These data underscore the importance of relationship process research in understanding developmental continuity and change. Although many early starters persist in their antisocial behavior, some desist (Dishion, Patterson, & Griesler, 1994). Moreover, some late-starters persist and escalate their antisocial behavior into adulthood. Patterson's analysis of adolescent problem behavior suggested that it was association with deviant peers that predicted growth (Patterson, 1993), regardless of time of onset. An analysis of friendship dynamics also suggested that those who organized their friendships in deviance also persisted in antisocial behavior. Considering the relationship dynamics associated with problem behavior provides an informative basis for considering risk.

The hypothesis that entropy and deviance would interact to predict adult antisocial behavior was supported only at age 14. The salience of age 14 friendships for developmental continuity might be explained by the premature autonomy hypothesis (Dishion, Nelson, & Bullock, in press; Dishion, Poulin, & Medici Skaggs, 2000). Families are seen as insulating youth from a tendency to form peer clusters that are autonomous from adult socialization influences (Sameroff & Suomi, 1996). We find that families of high-risk youth "give up" around puberty, as indicated by decreased efforts in monitoring and behavior management. Young adolescents' interactions with deviant peers and family disengagement synergistically predict adult antisocial behavior. It seems that youth involvement in such friendships may motivate an active effort to avoid parental involvement (see Stoolmiller, 1994) and, therefore, render the high-risk youth even more intractable to adult guidance.

An analysis of the developmental trends in the descriptive features of the boys' friendships is consistent with this concept of premature autonomy. At age 14, the antisocial and well-adjusted boys' friendships were about the same in terms of duration. However, as the antisocial boys matured, the duration of their friendships decreased, while the time they spent with their friends *increased*. The opposite trend was observed for the well-adjusted boys. These trends for the two groups are consistent with observations of family management, which remains high for the well-adjusted group and deteriorates for the antisocial boys throughout adolescence (Dishion et al., in press). In this way, it seems that adolescent deviance has a macrosocial function of connecting youth to the peer group while distancing the family in disengaging parent influence.

The implications of these findings for intervention are not trivial. We found that random assignment to interventions that aggregate high-risk peers can have an iatrogenic effect on early adolescent problem behavior (Dishion, McCord, & Poulin, 1999). The effects were most

pronounced for youth who received group attention for deviant talk and behavior in the groups (Dishion, Burraston, & Poulin, 2001). Apparently, young adolescents who organize their peer relationships around deviance may also respond to group interventions by mobilizing reinforcement for their behavior. In group settings managed by adults, reinforcement of peers (direct or indirect) is likely to overwhelm adult influence strategies (Buehler, Patterson, & Furniss, 1966).

The use of information theory and the entropy (H) index provides a useful tool for the analysis of friendship interactions as a relationship system. In particular, low levels of entropy are indicative of organized, patterned, and predictable transactions between two individuals. Dynamics such as "attractors" that are *not* predicated on reinforcement theory can be studied systematically. The findings from this study agree well with those from a previous analysis reported by Granic, Dishion, and Hollenstein (2003), with a different sample of high-risk young adolescents (males and females) and a measure of the duration of deviant talk as an indicant of a dyadic attractor. In this analysis, friendship dyads who tended to increase the length of their deviant talk bouts over the course of the 30-min observation were found to be more likely to escalate their problem behavior over the ensuing 2–3 years, controlling for prior levels of problem behavior. Taken together, it appears that the dynamic systems approach to focusing on how interactive dynamics of a friendship are organized is important for understanding friendship influence.

Of note, the entropy score is computationally similar to the other indices that test for pattern in transition matrices like the one analyzed in this study (see Gottman & Roy, 1990; Wickens, 1986). Additionally, the entropy index has several appealing features as a quantitative indicator of relationship dynamics:

1. It is based on *all* the observation data within a transition matrix, not merely those events defined a priori as theoretically meaningful.
2. The index is normally distributed and amenable to stochastic analytic approaches that assume a normal distribution.
3. The framework is quite general, therefore quantitative indices of entropy across studies and relationship contexts can be compared meaningfully, especially when the number of states across coding systems is identical.
4. The concept of entropy as an index of organization, complexity, and predictability unifies relationship psychology with a large body of science, providing a deeper understanding of relationship dynamics and their origins.

Entropy tells us that the friendship interactions are organized. More research is needed to identify the mechanism accounting for this important structural feature of relationships, in general, and friendship interactions, in particular. In psychological terms, a higher level of organization may be the product of increased attention, a shared understanding between two individuals on how to respond to observation tasks, motivation, practice, and skill. It would make sense that boys more interested in and motivated by deviant discussions would be those most likely to persist. However, the opposite also needs to be studied: To what extent are friendship dynamics and interpersonal competence prognostic of positive adult outcomes? The strategy used in this research for considering the contribution to deviance could just as well be used to understand the contribution of friendship to emerging adolescent competence.

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