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A longitudinal–experimental approach to testing theories of antisocial behavior development

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Abstract
A longitudinal study with a nested preventive intervention was used to test five hypotheses generated from developmental theories of antisocial behavior. The longitudinal study followed 909 boys from their kindergarten year up to 17 years of age. The randomized multimodal preventive intervention targeted a subsample of boys who were rated disruptive by their kindergarten teacher. Semiparametric analyses of developmental trajectories for self-reported physical aggression, vandalism, and theft identified more types of trajectories than expected from recent theoretical models. Also, these trajectories did not confirm theoretical models, which suggest a general increase of antisocial behavior during adolescence. The majority of boys were on either a low-level antisocial behavior trajectory or a declining trajectory. Less than 6% appeared to follow a trajectory of chronic antisocial behavior. Comparisons between disruptive and nondisruptive kindergarten boys confirmed the hypothesis that disruptive preschool children are at higher risk of following trajectories of frequent antisocial behavior. Comparisons between treated and untreated disruptive boys confirmed that an intensive preventive intervention between 7 and 9 years of age, which included parent training and social skills training, could change the long-term developmental trajectories of physical aggression, vandalism, and theft for disruptive kindergarten boys in low socioeconomic areas. The results suggest that trajectories of violent behavior can be deflected by interventions that do not specifically target the physiological deficits that are often hypothesized to be a causal factor. The value of longitudinal–experimental studies from early childhood onward is discussed.

There is probably no area of behavior or psychiatric disorder riper for an experimental design than conduct disorder.

Lee N. Robins (1992, p. 11)

During the last two decades many theories of antisocial behavior adopted a developmental perspective. The main consensus appears to be that chronic antisocial behavior after preadolescence is the continuation of a pattern that begins in childhood (e.g., Gottfredson & Hirschi, 1990; Lahey, Waldman, & McBurnett, 1999; Loeber, 1990; Lynam, 1996; Moffitt, 1993a; Sampson & Laub, 1992). These theories specify both the developmental trajectories of the phenomena over time and the factors that are responsible for a person's trajectory of antisocial behavior. The present study aims at testing some theoretical assumptions about antisocial behaviors by identifying developmental trajectories with a longitudinal cohort design and testing the effects

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of hypothetical causal factors on trajectories of antisocial behaviors with a randomized experimental preventive intervention design.

Testing Developmental Theories

Recent developmental theories of antisocial behavior differ with respect to the number of developmental trajectories that individuals are postulated to follow. For instance, Gottfredson and Hirschi (1990) suggested the existence of a single pathway, starting with low levels of self-control in childhood and leading to criminality later in life. Moffitt (1993a) distinguished between two groups of antisocial individuals: those who are antisocial across the life course and those whose antisocial behavior is limited to adolescence. Loeber and colleagues (Loeber, 1991; Loeber et al., 1993) suggested three distinct antisocial pathways: overt (violent), covert (property offences), and conflict with authority pathways.

These developmental theories are largely based on data from longitudinal studies submitted to analytical techniques that allowed investigation for the presence of a priori defined groups. More recently, new statistical methods using an inductive approach with prospective longitudinal studies were used to examine developmental taxonomies. An important advantage of this approach is that it avoids the use of subjectively (and a priori) defined criteria for categorizing people in distinct groups. For instance, semiparametric statistical analyses using a statistical criterion for model selection are particularly well suited to test the extent to which there are groups in a population that follow distinct developmental trajectories (Jones, Nagin, & Roeder, 2001; Nagin, 1999; Nagin & Land, 1993; Nagin & Tremblay, 2001). Studies using this methodology have revealed the existence of several distinct groups of developmental trajectories of antisocial behavior from childhood to adolescence. For example, a longitudinal study of male physical aggression from 6 to 15 years of age identified two groups of boys with declining levels, a group with stable low levels, and a group with chronically high levels (Nagin & Tremblay, 2001). Similar results were obtained with samples of boys and girls from longitudinal studies in Canada, New Zealand, and the United States (Brame, Nagin, & Tremblay, 2001; Broidy et al., in press; Côté, Zoccolillo, Tremblay, Nagin, & Vitaro, 2001; Nagin & Tremblay, 1999). Thus, studies using statistical criteria to generate taxonomies have uncovered a larger number of distinct developmental trajectories as compared to studies using a priori defined taxonomies.

Testing Factors Leading to Differing Developmental Trajectories

An underlying assumption of developmental models is that different causal factors will lead to different developmental trajectories and in some cases to different trajectories for different types of antisocial behavior. Thus, Gottfredson and Hirschi (1990) attribute the origin of all forms of antisocial behavior to parents' inability to foster self-control in their children. Moffitt (1993b) suggests that neuropsychological deficits present at birth provide the starting point for a life course persistent trajectory of antisocial behavior, whereas the maturity gap between adolescence and adulthood is proposed to drive adolescence-limited delinquency. Others have suggested an accumulation of causal factors (Coie, Watt, West, et al., 1993; Loeber, 1990; Yoshikawa, 1994).

Several other models have also emphasized the importance of parenting (e.g., McCord, 1991; Shaw & Bell, 1993). For instance, Patterson and colleagues (Patterson & Reid, 1984; Patterson, Reid, & Dishion, 1992) postulated that deficient parenting was involved in the emergence of coercive family interactions that reinforce and maintain behavior problems. Similarly, Hawkins and Weis (1985) proposed that a negative family environment interferes with children's acquisition of adequate social skills, which increases the potential for behavior problems.

These models imply that interventions that would target putative causal factors such as parenting practices, children's cognitive deficits, or children's social skills have the potential to modify the postulated developmental trajectories. Thus, adequately assessed preventive and corrective interventions that tar-

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get postulated causal factors are not only pragmatic tests of an intervention's effectiveness, they also offer an exceptional opportunity to test causal hypotheses of developmental theories (Cicchetti & Toth, 1992; Farrington, Ohlin, & Wilson, 1986; Kellam & Rebok, 1992; Koretz, 1991; Robins, 1992; Schwartz, Flamant, & Lellouch, 1980; Tonry, Ohlin, Farrington, 1991; Tremblay & Craig, 1995; Vitaro, Brendgen, & Tremblay, 2001; Vitaro, Brendgen, Pagani, Tremblay, & McDuff, 1999). Indeed, demonstrating that an intervention that successfully changes a postulated causal factor also effectively modifies a trajectory of antisocial behavior can be considered an experimental test of a causal theory, and thus a better test than correlational evidence from a prospective longitudinal study.

However, there is a way of harnessing the power of both experimental and prospective longitudinal studies. By nesting a preventive or corrective experiment within a longitudinal study, different characteristics of developmental theories can be tested. For example, the longitudinal study can be used to test the types of developmental trajectories that exist in a given population and the preventive or corrective intervention can test whether the developmental trajectories have been modified by manipulating those variables that the theoretical models suggest to be causal factors. Furthermore, such a design can test whether there are different types of developmental trajectories for different types of behavior, as well as to what extent a given intervention can have an impact on trajectories for different types of behavior. For instance, a longitudinal–experimental design can first test whether there are significant groups of early- and late-onset cases of antisocial behavior and then test whether increasing parenting skills can move children from an early-onset trajectory of antisocial behavior to a trajectory of rapid or slow desistance. Furthermore, such designs can also test whether children who were deflected from an early-onset trajectory maintain low levels of antisocial behavior throughout adolescence or become involved again in frequent antisocial behaviors when factors thought to be related to an adolescent-onset trajectory start appearing. One would indeed expect that individuals deflected from an early-onset trajectory by an early intervention would be more at risk of an adolescence-onset trajectory if there are no further interventions targeting risk factors during adolescence (Tremblay, Pagani–Kurtz, Mâsse, Vitaro, & Pihl, 1995).

The Present Study

The general aim of the present study was to test hypothetical taxonomies of antisocial behavior development and their causal factors by using data from a longitudinal–experimental study. We tested five hypotheses. We first addressed the issue of developmental taxonomies. To achieve this general objective we identified groups of boys who followed, during adolescence, distinct developmental trajectories for three types of antisocial behaviors: physical aggression, vandalism, and theft. In so doing, we first tested whether the number (hypothesis 1) and shape (hypothesis 2) of the trajectories were consistent with predictions from developmental theories. We also tested the hypothesis that disruptive children at school entry were more at risk of following high-level antisocial trajectories during adolescence (hypothesis 3).

The second general objective was to assess the impact of the experimental prevention program on developmental trajectories of antisocial behavior. The intervention was nested within the prospective longitudinal study. The multimodal program targeted parents' management skills and children's social–cognitive skills. This program has been shown to have a significant impact on parental supervision, disruptive behavior, and association with deviant peers (Vitaro et al., 1999, 2001). We first examined whether targeting hypothetical causal factors, such as parents' management skills and children's social–cognitive skills, had an impact on trajectories of physical aggression, vandalism, and theft (hypothesis 4). In cases where the experimental intervention had a significant impact, we tested the differential effect of the intervention on types of trajectories; more specifically, we tested whether frequent antisocial behavior reemerged at a given point in time during adolescence or

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whether the intervention had a long-term impact and thus prevented the reemergence of frequent antisocial behavior (hypothesis 5).

Method

Sample

The subjects were part of a longitudinal study that began in 1984. All males, from kindergarten classes in 53 schools of low socioeconomic areas of Montreal, Canada, were recruited. The sample was reduced from 1,161 to 1,037 participants by creating a homogeneous sample of French-speaking children whose parents were born in Canada and by eliminating subjects who refused to participate or could not be traced. For the present paper, we used 909 boys (87.7%) who responded to a self-reported antisocial behavior questionnaire at least three times when they were between 11 and 17 years of age.

At their first assessment in kindergarten, 67% of the boys lived with both parents and 24% lived with their mothers only. The mean age of parents at birth of the child was 25.4 years (SD = 4.8) for mothers and 28.4 years (SD = 5.6) for fathers. The mean number of school years completed by the parents was 10.5 (SD = 2.8) for the mothers and 10.7 (SD = 3.2) for the fathers. The mean score on the Canadian socioeconomic index for occupations (Blishen, Carroll, & Moore, 1987) was 38.15 for mothers and 39.19 for fathers.

Using the disruptiveness scale of the Social Behavior Questionnaire (SBQ; Tremblay et al., 1991), teachers rated boys' behavior at the end of kindergarten, when they were turning 6 years of age. The disruptiveness scale includes 13 items, which measure hyperactive, aggressive, and oppositional behaviors. Teachers indicated whether items: did not apply (0), applied sometimes (1), or applied often (2). Internal consistency was high (α = .87). Those who received scores above the 70th percentile on the SBQ disruptiveness scale in kindergarten (n = 259) were classified as disruptive and considered at risk for antisocial behaviors during adolescence. The 259 disruptive boys were randomly assigned to one of the following groups: (a) intervention group (IN group; n = 75); (b) no treatment control group (CO group; n = 60); and (c) sensitization contact group (SC group; n = 124). The numbers of participants were reduced to 42 (IN group), 41 (CO group), and 74 (SC group) because of missing data on the variables of interest and because some parents refused to participate in the study. The boys who were lost in each group (due to refusal or missing data) did not differ across the three groups. The SC group was included to control for the possible influence of mere contact with researchers and participation in the study. Over a 6-year period, every 2nd year, the boys in the SC group participated in the following activities: (a) they spent one-half of a day with their families in the university laboratories to participate in a series of tests and observation sessions; (b) families were visited during four evenings for observations in the home setting; (c) each boy was observed at school for half a day on four occasions; and (d) each boy spent a whole day in the university laboratories during the summer. In contrast, CO boys were only followed through questionnaires sent to parents and teachers during the intervention period. They were then met once a year at school to fill in questionnaires which included the self-reported antisocial scales.

Analyses revealed that boys in the SC and CO groups did not differ on any variable measured at pre- or posttest. Therefore, it was decided to collapse the CO and SC boys into one group (i.e., CO group) to increase statistical power.

Prevention program

The prevention program was implemented over a 2-year period from ages 7 to 9. The program included two main components (i.e., social skills training with the children and improvement of parenting skills) that were believed at that time to be most likely to alter the boys' disruptive behaviors (Kazdin, 1985). It was expected that they would become less disruptive if they learned alternate and more appropriate social behaviors through social skills training (Milan & Kolko, 1985). Improvement of parenting skills (i.e., use of rein-

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forcement contingencies and sustained supervision) was also used as a strategy to reduce disruptive behaviors at home and facilitate the generalization and consolidation of the skills learned by the children at school.

Social and problem-solving skills training was conducted at school in small groups. Four trained professionals (two child-care workers, one social worker, and one psychologist) conducted the sessions. In each group, there were four or six teacher-nominated prosocial boys and one or two target boys. Including the prosocial boys in the sessions served two purposes. First, they were positive models and reinforcement agents. Second, their presence allowed the target children to participate without being stigmatized by classmates. The school-based biweekly training sessions took place between November and April for 2 consecutive years. Each session lasted approximately 45 min. Verbal instructions, positive reinforcement, modeling, and behavioral rehearsal were used to teach the specific skills to the target boys.

Parent training was adapted from the program developed by the Oregon Social Learning Center (Patterson, Reid, Jones, & Conger, 1975). The same four professionals who conducted the social and problem solving sessions at school, conducted the parent training sessions in the boys' homes. However, to stimulate teamwork among the professionals, each family had different professionals for parent training and for social skills training. Parents were first taught to recognize, observe, and record their children's problem behaviors. Next, they were taught to define appropriate behaviors and to set clear objectives for their child. Third, they learned how to use verbal and material reinforcement in a systematic and contingent manner to favor the child's acquisition of appropriate behaviors. Parents also learned to punish inappropriate behavior systematically and moderately with short time-out periods. Response-cost strategies involving the use of naturally occurring consequences for inappropriate behavior were also used (i.e., if the child broke something that did not belong to him, he had to replace it). Parents were encouraged to supervise their children's schoolwork and monitor their child's behavior outside the home. Finally, parents were taught how to manage family crises through problem solving and how to use negotiation strategies in everyday situations.

Parents participated in an average of 17.4 sessions (SD = 13.2; median = 15). The maximum was 47. Six families participated in only two training sessions. For most of the families, the number of training sessions required depended on how well the therapist believed the parents had mastered the targeted skills. For 14 families, however, the training ended prematurely because the parents were unmotivated. The boys from these families were nevertheless kept in the IN group for the purpose of the following analyses.

Implementation assessment. At the end of each child or parent session, the professionals responsible for the program application indicated whether the session had taken place and the percentage of content delivered during the session relative to a preplanned standardized content. More than 85% of the children attended at least two-thirds of the social skills training sessions. For parents, the number of sessions varied greatly. Despite variation, more than 75% of the parents covered at least two-thirds of the content and objectives of the parent training component. In addition, child sessions were videotaped and parent sessions were audiotaped; these tapes were used by the program coordinator to give weekly feedback to each of the professionals and maintain the standardization of the program.

Measures

Self-reported antisocial behaviors. In the present study, we measured three facets of antisocial behaviors: physical aggression, vandalism, and theft. These subscales are in part of a more general antisocial behavior questionnaire (Tremblay, Pihl, Vitaro, & Dobkin, 1994). Physical aggression was assessed by creating an index based on the frequency, during the previous 12 months, of 7 self-reported behaviors: threatening to attack someone, fist fighting, attacking someone innocent, gang fighting, throwing objects at people, carrying

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weapons, and using weapons in a fight. The internal consistency (Cronbach's alpha) for this subscale was .72–.81 (M = .77). Vandalism was assessed by 6 items: destroying or breaking music or sports equipment at school, destroying or breaking somebody else's things, destroying or breaking windows at school, destroying or breaking something that belongs to the parents, destroying or breaking parts of a car (antenna, tires, etc.), and setting a fire. The internal consistency (Cronbach's alpha) for this subscale was .59–.77 (M = .68). Theft was assessed by 11 items: stealing from a store, stealing something worth less than $10, keeping objects worth more than $10 at school, stealing something more then $100, entering an event without paying admission, stealing money from home, stealing a bicycle, stealing something worth between $10 and $100, buying stolen goods, being in an unauthorized place, and breaking and entering. The internal consistency index for the scale was 0.76–0.87 (M = 0.83). These items are all coded on a 4-point Likert scale (0 = *never,* 1 = *once or twice,* 2 = *sometimes,* 3 = *often*) and were answered every year at ages 11–17.

Analysis

The analysis proceeded in two separate steps. Using the whole sample, we first identified the best fitting trajectory models for physical aggression, vandalism, and theft. Then we compared the trajectories followed by different subgroups: the IN group, the CO group, and the nondisruptive kindergarten boys.

To identify the trajectories we used a group-based method described in Jones, Nagin, and Roeder (2001), Land and Nagin (1996), Nagin (1999), Nagin and Land (1993), and Roeder, Lynch, and Nagin (1999). A finite mixture of Poisson distributions was used to identify distinctive clusters of individual trajectories within the sample.

Similar to hierarchical or latent growth curve modeling, a polynomial relationship is used to link age to behavior with the following quadratic equation:

$$\log(\lambda_{it}^{j}) = \beta_0 j + \beta_1^{j} \text{ age}_{it} + \beta_2^{j} \text{ age}_{it}^{2},$$

where λ_{it}^{j} is the rate of physical aggression, vandalism, and theft for individual i at age t given membership in group j. Age_{it} is the participant's age at time t; age_{it}^{2} is the square of subject i's age at time t; and β_0^{j}, β_1^{j}, β_2^{j} are the maximum likelihood coefficients estimated by the model to fit the trajectory. The superscript j means that these parameters can differ across the j groups. For any given j, conditional independence is assumed for the sequential realizations of the elements λ_{it} over the t periods of measurement.

A key issue in the application of a group-based model is determining how many groups define the best fitting model. We followed the lead of D'Unger, Land, McCall, and Nagin (1998) and used the Bayesian Information Criterion (BIC) as a basis for selecting the optimal model.

Using the "posterior probability" of membership to a trajectory, every individual was assigned to the trajectory that best conforms to his behavior over time. Following this maximum probability assignment rule, trajectory membership was made conditional on membership in the intervention, control, and low-risk groups. We used one-tailed t tests to test for significant differences in probabilities of following a specific trajectory conditional on the treatment conditions (i.e., CO group, IN group, and low-risk [nondisruptive] group).

Results

The results are reported in two parts. We first present findings on the number, shape, and prevalence of trajectories for physical aggression, vandalism, and theft using the whole sample (hypotheses 1 and 2). We then examine whether membership in the IN, CO, and low-risk groups distinguishes trajectory group membership (hypotheses 3–5). Recall that the control and intervention groups were created by random assignment of boys displaying high levels of disruptive behavior in kindergarten (age 6). The low-risk group comprises all boys below this threshold. Of specific interest for hypothesis 3 is whether boys in the high-risk group who received no treatment (i.e., the CO group) are more likely to follow higher level trajectories of antisocial behavior

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during adolescence compared to the low-risk group. We then test whether the intervention group is (a) significantly less likely than the control group to follow such high-level antisocial trajectories, (b) correspondingly more likely to follow a trajectory of low-level antisocial behavior, and (c) follows trajectories that are similar to those of the low-risk group (hypothesis 4). Finally, we compare the trajectory group memberships of the IN and low-risk groups specifically for the rising trajectories to assess if a short-term impact of the intervention was followed by a later increase in antisocial behavior (hypothesis 5).

Hypotheses 1 and 2

For each of the three types of antisocial behaviors, a six-group model was chosen as the best model. In this analysis, the BIC score continued to improve after six groups had been identified. However, after these six groups, the new groups were simply subdivisions of already existing groups who engaged in low levels of antisocial behavior. Specifically, the procedure tended to split large groups of boys with infrequent antisocial behavior into two parallel trajectories while leaving the high level trajectories intact. We chose the six-group model because in our judgement it is the most parsimonious and informative model.

Figure 1 presents the shape of the trajectory groups for the three dependent variables: physical aggression, vandalism, and theft. They vary widely in shape; some are rising, some are declining, some are high, and some are low. The shapes of the trajectories show some similarities across the three different types of antisocial behaviors. Table 1 describes the percentage of individuals in the sample following the different developmental trajectories. One group, termed high rising, comprises individuals with a high rate of antisocial behaviors throughout the adolescent period that reaches a peak at around age 16. Across the three types of antisocial behavior, from 4.4 to 5.8% of the sampled population belong to the high rising trajectory. A second group, labeled medium decline, starts with a high rate of antisocial behavior and tends to be relatively stable or slightly decline through age 17. A somewhat greater proportion of individuals followed this trajectory compared to the high rising trajectory for physical aggression (12%); proportions are similar for vandalism (5.9%) and theft (6.9%). Subjects on the low rising trajectory group start at a relatively low level and steadily increase their rate of antisocial behaviors throughout adolescence. For physical aggression and vandalism this group is estimated to comprise 11.4 and 6.9%, respectively, of the population. For theft the estimated size of this group is larger, 16.4% of the population. An even larger group followed a trajectory that we termed low decline because the level starts relatively low at age 11 and declines until age 17. For physical aggression 26.3% of the population are estimated to follow this trajectory. For vandalism and theft the corresponding group membership probabilities are 11.1 and 14.2%, respectively. Finally, close to half of the population is estimated to be on the two low-level trajectories: 29.9 and 15.6% for physical aggression, 58.0 and 13.6% for vandalism, and 32.2 and 24.4% for theft.

Hypothesis 3

Figure 2 presents the conditional probabilities linking the control, intervention, and low-risk groups to the developmental trajectories from ages 11 to 17. As expected, the control group had the smallest probability of following the low-level trajectory for each specific behavior. Specifically, 18.3, 46.1, and 27.0% of the CO group followed the Low 1 trajectories of physical aggression, vandalism, and theft, respectively. By contrast, the counterpart probabilities are substantially larger for the low-risk group: 31.6, 59.4, and 33.1%, respectively. As shown in Table 2, these differences are statistically significant at $p < .001$ with the exception of theft, at $p < .09$. This pattern reverses itself for the highest level trajectories. The CO group has greater probabilities of following the medium decline and high rising trajectories than the low-risk group. We combined the two highest trajectories for the difference tests because the probabilities are small and otherwise would create statistical power problems.

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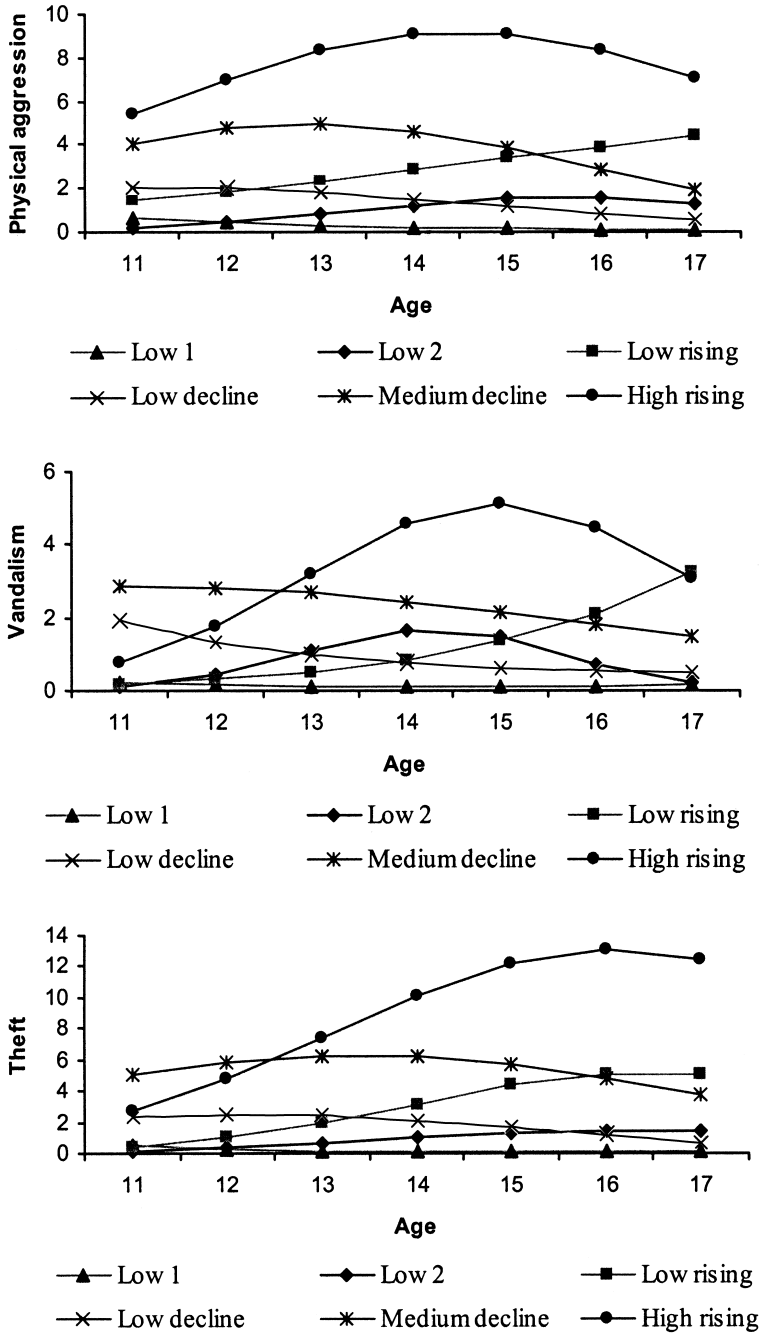


Figure 1. Developmental trajectories of physical aggression, vandalism, and theft throughout adolescence.

For physical aggression, 29.5% of the CO group follow these combined trajectories, whereas among the low-risk group, only 14.7% belong to one of these high-level trajectories. For vandalism, the counterpart membership rates are 17.4% for the controls and 9.3% for the low risks, and for theft the rates are 20 and 12%, respectively, for the control and low-risk groups. The control group is significantly more likely than the low-risk group to follow

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Table 1. *Prevalence of trajectory groups for physical aggression, vandalism, and theft*

	Low 1	Low 2	Low Rising	Low Decline	Medium Decline	High Rising
Physical aggression						
Control	18.3	11.3	10.4	30.4	21.7	7.8
Intervention	31.0	16.7	7.1	28.6	9.5	7.1
Low risk	31.6	16.2	11.8	25.5	10.6	4.1
Total sample	29.9	15.6	11.4	26.3	12.0	4.7
Vandalism						
Control	46.1	9.6	12.2	14.8	9.6	7.8
Intervention	64.3	11.9	4.8	9.5	7.1	2.4
Low risk	59.4	14.4	6.3	10.6	5.3	4.0
Total sample	58.0	13.6	6.9	11.1	5.9	4.4
Theft						
Control	27.0	20.9	18.3	13.9	12.2	7.8
Intervention	31.0	33.3	14.3	14.3	2.4	4.8
Low risk	33.1	24.5	16.2	14.2	6.4	5.6
Total sample	32.2	24.4	16.4	14.2	6.9	5.8

the combined medium decline and high rising trajectories of physical aggression ($p < .00$), vandalism ($p < .01$) and theft ($p < .02$).

Hypotheses 4 and 5

To test the short- (hypothesis 4) and long-term (hypothesis 5) impact of the intervention, we compared the differences in trajectories between the intervention group and two other groups: first with the control group to compare disruptive kindergarten boys with and without the preventive intervention, and second with the low-risk boys (not disruptive in kindergarten) to see to what extent the intervention was successful in reducing the difference described, in the previous section, between high- and low-risk kindergarten boys.

As hypothesized, the intervention group has higher probabilities of following the Low 1 trajectory of physical aggression, vandalism and theft compared to the control group. The respective probabilities for the two groups were 31.0 versus 18.3% for physical aggression, 64.3 versus 46.1% for vandalism, and 31.0 versus 27.0% for theft. Group differences are significant for physical aggression and vandalism ($p < .05$) but not significant for theft. We observe the opposite trend for the two highest trajectories combined. The intervention group is less likely than the control group to follow these high-level trajectories of physical aggression (16.6 vs. 29.5%), vandalism (9.5 vs. 17.4%), and theft (7.2 vs. 20%). These differences are significant for physical aggression ($p < .04$) and theft ($p < .01$) and close to significance for vandalism ($p < .08$).

The second set of analyses shows that the preventive program not only created significant differences between the IN and CO groups, but it also apparently eliminated differences between the IN group and the low-risk groups in terms of trajectory group conditional probabilities. For physical aggression, 31.0 and 31.6% of the intervention and low-risk groups, were respectively assigned to the low-level trajectories. At the other end of the physical aggression spectrum, 16.6% of the intervention group were estimated to follow the medium declining or high rising trajectory, nearly identical to the membership probability for the low-risk group (14.7%). Similar results were observed for the vandalism and theft trajectories.

Finally, the intervention could have deflected the disruptive boys from higher to lower level trajectories, but only for the first few years after the intervention. If this were

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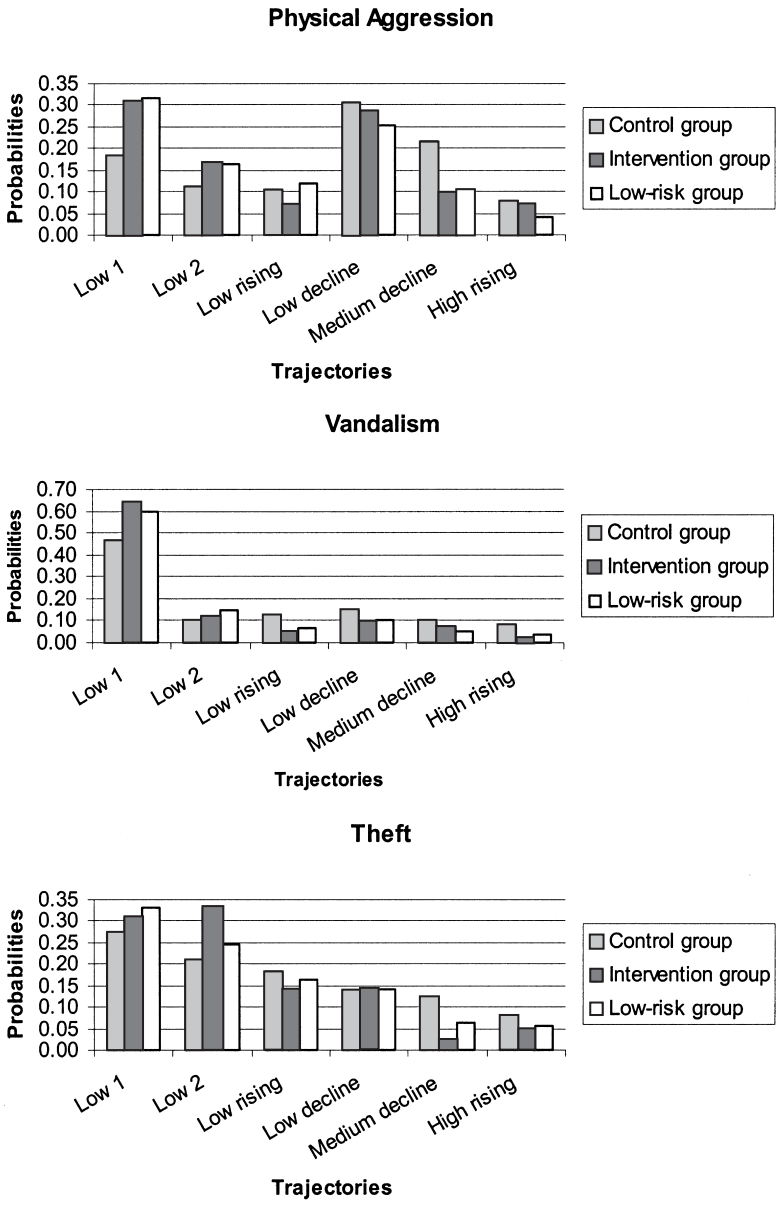


Figure 2. Physical aggression, vandalism, and theft trajectory probabilities conditional on low-risk, control, and intervention group membership.

the case, we would expect to find more of the IN group than the CO group boys on the low rising trajectories (hypothesis 5). Statistical analyses did not show any significant differences between the intervention and the control group for physical aggression (7.1 vs. 10.4%), vandalism (4.8 vs. 12.2%), and theft (14.3 vs. 18.3%). Moreover, there were no significant differences between the intervention and low-risk groups for the percentage of boys who followed a low rising trajectory.

Discussion

The aim of the present study was to use a prevention experiment nested in a longitudinal

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Table 2. *The p values for differences in percentages of boys in the low-risk group, control group, and intervention group who followed two trajectories during adolescence*

Comparisons	Low 1	Medium Decline–High Rising
Physical violence		
Control group vs. low-risk groups	.00	.00
Intervention group vs. control group	.05	.04
Intervention group vs. low-risk group	.47	.37
Vandalism		
Control group vs. low-risk group	.00	.01
Intervention group vs. control group	.02	.08
Intervention group vs. low-risk group	.26	.48
Theft		
Control group vs. low-risk group	.09	.02
Intervention group vs. control group	.31	.01
Intervention group vs. low-risk group	.39	.13

study to test developmental hypotheses of antisocial behavior. We first tested hypothetical taxonomies for trajectories of antisocial behavior development with the longitudinal data and then tested the impact of the preventive intervention on the developmental trajectories.

The first two hypotheses dealt with the number and shape of developmental trajectories for physical aggression, vandalism, and theft. The semiparametric analyses indicated that the boys followed at least six types of trajectories for each of these three forms of antisocial behavior from 11 to 17 years of age. These results display important heterogeneity in the development of antisocial behavior and confirm previous studies using the same analytical methodology (e.g., Brame et al., 2001, Broidy et al., in press; Nagin, Farrington, & Moffitt, 1995; Nagin & Land, 1993; Nagin & Tremblay, 2001). The results clearly indicate that, in contrast to the recent developmental theories of antisocial behavior, there are more than two or three developmental paths for antisocial behavior during adolescence. We did observe a small group of subjects who showed a high level of antisocial behavior throughout adolescence and could be considered chronic cases (i.e., the high rising group). This was seen most clearly for physically aggressive behavior. The high rising group had the highest level of physical aggression at the first measurement point, and it remained highest at every other assessment. The patterns for vandalism and theft appear different from the physical aggression trajectory. For vandalism, the two groups with the highest level at first assessment showed declining trajectories and, by age 17, had medium and low levels compared to the other four groups. For theft, the group with the highest level at the first assessment remained almost at the same level until age 17, but it was by then overtaken by two other groups who were on a rising trajectory. Thus, we did observe groups of subjects whose antisocial behavior increased substantially from the preadolescent to adolescent years. However, we did not observe, as predicted by the "age crime curve" hypothesis (e.g., Farrington, 1987; Quetelet, 1833), that there was a substantial increase in physically violent offending during adolescence. Only 11.4% of the subjects were on a rising trajectory of physical aggression. We also failed to find support for the more recent "late onset hypothesis" (Moffitt, 1993a; Patterson, DeBaryshe, & Ramsey, 1989), that there is a large percentage of individuals who increase their level of antisocial behavior during adolescence to the point that they become undistinguishable from those with a chronic pattern. Those who at ages 11 and 12 had the highest level of physical aggression (i.e., high rising, 4.7%) never had any rivals, but those who at the same age appeared to be on the chronic trajectory for vandalism and theft (i.e., medium decline, 5.9 and 6.9%, respectively) did ultimately have rivals, because they eventually were in fact largely outperformed by boys

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who had started at substantially lower levels (i.e., high rising, 4.4 and 5.8%, respectively). Note also the very small percentage of boys involved in the latter trajectories that could be considered "late-onset" vandalism and theft. Finally, we observed that a substantial number of boys were following a declining trajectory of antisocial behavior from 11 to 17 years of age. To our knowledge, none of the developmental theories of antisocial behavior predicted this phenomena. In the case of physical aggression, the declining trajectories (38.3%) are probably the extension of the general decline in frequency of physical aggression that appears to start in early childhood (Tremblay, 2000). The number of subjects on a declining trajectory for vandalism (17.0%) and theft (21.1%) is also important. These appear to mirror the decline in physical aggression and may be the result of a general socialization process. However, to our knowledge, no data has been published on the development of vandalism and theft from early childhood to adolescence, and consequently we do not know the developmental links between physical aggression, vandalism, and theft. It is interesting that there are more boys on a low level trajectory for vandalism and theft than for physical aggression. We clearly need longitudinal studies with repeated measurements of different forms of antisocial behavior from early childhood to adolescence, in order to understand the different pathways for different types of antisocial behavior.

To test our third hypothesis, we compared the developmental trajectories of disruptive kindergarten boys who were not in the experimental intervention with their nondisruptive counterparts. Results supported the numerous developmental models of antisocial behavior since the pioneering work of Robins (1966), which predict that disruptive children are more likely to follow a chronic antisocial behavior trajectory. Consistent with these predictions, the result showed that disruptive kindergarten boys are less likely to be on low-level trajectories of antisocial behavior and more likely to follow high-level trajectories. These results were clearest for physical aggression and for theft, with vandalism in between. Such results not only support theoretical models that suggest that disruptive behavior during early childhood is an important antecedent of antisocial behavior during adolescence, they also reinforce the idea that the prevention of adolescent antisocial behavior should start during early childhood (e.g., Kellam & Rebok, 1992; Robins, 1992; Tremblay, LeMarquand, & Vitaro, 1999; Tremblay et al., 1992; Yoshikawa, 1994).

Having shown that disruptive kindergarten boys who did not participate in the preventive intervention were at higher risk of following a high-level antisocial trajectory and less likely to be on a low-level antisocial trajectory, we then proceeded to test whether a preventive intervention targeting the disruptive kindergarten boys and their families would deflect them to a low-level antisocial behavior trajectory. It was hypothesized that intensive parent training and social skills training over a 2-year period, at the start of elementary school, would change the course of their antisocial behavior not only during the preadolescent years but also throughout adolescence. Results confirm this hypothesis, especially for physical aggression. Boys from the IN group compared to those from the CO group were more likely to follow the lowest level trajectory and less likely to follow high-level trajectories. We also did not observe any differences in the probability of following specific physical aggression trajectories between the boys from the IN group and those from the low-risk group.

To our knowledge, this is the first demonstration that an intervention with disruptive children has shown such a significant impact on the developmental course of physical aggression. In fact, we have found no evidence in the literature of an intervention program with a long-term follow-up that showed any significant reduction in levels of physical aggression. The results from the present study are impressive because the intervention could have had a significant impact by simply deflecting some of the high-risk boys from a medium-level trajectory to a low-level trajectory. However, the analyses do indicate that the high-risk boys who participated in the intervention were moved from high-level trajectories to lower level trajectories. Furthermore,

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there is no evidence that those who were deflected to the lower trajectories after the intervention had problems later on that would have placed them on a rising trajectory. Thus, the impact of the intervention for physical aggression was to put a statistically significant number of the high-risk boys on the same developmental trajectories as the low-risk boys. The intervention appeared to have a similar impact on the trajectories for vandalism, except that the comparison between the IN and CO groups showed only a marginally significant effect on those who were following the high-level trajectories. For theft, there was also a significant impact of the intervention according to comparisons of the IN and CO groups. In contrast to physical aggression and vandalism trajectories, boys in the intervention group were more likely to follow the Low 2 instead of the "Low 1" trajectory.

We offer both a theoretical and a methodological explanation for the apparently differential impact of the intervention on trajectories of physical aggression, vandalism, and theft. First, although we partially confirm theoretical models of general deviance during adolescence for the early-onset disruptive group (Gottfredson & Hirschi, 1990; Jessor & Jessor, 1977), the developmental trajectories of physical aggression, vandalism, and theft may not be driven by the same distal and proximal causal factors. Hence, an intervention targeting parent training and social skills training may impact differentially on physical aggression, vandalism, and theft. From this perspective, the intervention that was aimed at disruptive behavior may not have dealt sufficiently with factors leading to high-level trajectories of vandalism, for example. The alternative methodological explanation is one of statistical power. Indeed, because the trend of the results is all in the same direction, we may not have had the statistical power to detect all the positive impacts of the intervention.

In summary, the present study used two methodological innovations to test developmental theories of antisocial behavior. A preventive experimental intervention was nested within a longitudinal study, and developmental trajectory analyses were employed to test the differential impact of the intervention on subgroups defined by different developmental trajectories found in the longitudinal study. The results showed that recent developmental theories of antisocial behavior have underestimated the number of developmental trajectories for antisocial behavior. There are clearly many developmental trajectories for any given type of antisocial behavior, and there are possibly different types of developmental trajectories for different types of antisocial behavior. Developmental theories that attempt to address the whole domain of antisocial behavior will need to take this complexity into account, as well as consider the added complexity generated by the associations among the different types of antisocial behavior over time, which we may label developmental comorbidity. Second, results confirmed that disruptive kindergarten children are at high risk for antisocial behavior during adolescence. Third, the impact of the experimental intervention confirmed that a relatively early and intensive intervention could change the developmental course of physical aggression, vandalism, and theft followed by boys who leave kindergarten with disruptive behavior problems. Thus, disruptive behavior during the preschool years is not destiny. Furthermore, the developmental trajectories of physical aggression for disruptive kindergarten boys appear to be amenable to deflection by interventions that do not specifically target the neuropsychological deficits often hypothesized to cause chronic physical aggression (e.g., Arseneault, Tremblay, Boulerice, & Saucier, in press; Arseneault, Tremblay, Boulerice, Séguin, & Saucier, 2000; Moffitt, 1993b; Raine, 1993; Raine, Brennan, & Mednick, 1997; Séguin, Pihl, Harden, Tremblay, & Boulerice, 1995). Interventions targeting social behavior may help children adjust to their social environments without necessarily modifying underlying physiological deficits, or they may have an indirect impact on these deficits (Keating & Hertzman, 1999).

The study had a number of important limitations. First, the longitudinal data that were used to trace developmental trajectories of antisocial behavior used only self-report and were limited to the period between 11 and 17 years of age. There is good evidence, includ-

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ing from the present study, that antisocial behavior problems start during the preschool years (Hay, Castle, & Davies, 2000; Keenan & Wakschlag, 2000; Loeber & Farrington, 2000; Tremblay, 2000). To fully understand developmental trajectories of antisocial behavior and their transformation by preventive interventions, we need studies that trace these developmental trajectories from early childhood to adulthood. A second important limitation of the study was the relatively small group of subjects submitted to the intervention. This not only resulted in low statistical power but also prevented more sophisticated analyses, such as the effect of the intervention on joint trajectories to explore its impact on comorbidity. Although the intervention showed a significant long-term impact on physical aggression, vandalism, and theft, it was applied to a specific group of male subjects in a given context, and replications will be needed to assess the extent to which these results can be generalized. Preventive studies with disruptive girls will be especially useful in clarifying the extent to which the present results can be generalized across gender in similar, and different contexts. Future studies will also need to investigate risk factors associated with each of these trajectories and possible interaction effects of these risk factors with the intervention. Such studies will also need to include dose–response and cost-effectiveness analyses.

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