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Testing Three Explanations of the Emergence of Weapon Carrying in Peer Context: The Roles of Aggression, Victimization, and the Social Network

Jan Kornelis Dijkstra, Ph.D.^{a,b,*}, Scott D. Gest, Ph.D.^c, Siegwart Lindenberg, Ph.D.^{a,b}, René Veenstra, Ph.D.^{a,b,d}, and Antonius H. N. Cillessen, Ph.D.^e

^a Department of Sociology, University of Groningen, Groningen, The Netherlands

^b Interuniversity Center for Social Science Theory and Methodology, The Netherlands

^c Department of Human Development and Family Studies, Pennsylvania State University, State College, Pennsylvania

^d Department of Psychology, University of Turku, Turku, Finland

^e Department of Developmental Psychology, Behavioural Science Institute, Radboud University Nijmegen, Nijmegen, The Netherlands

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A B S T R A C T

Purpose: To examine the relative contribution of weapon carrying of peers, aggression, and victimization to weapon carrying of male and female adolescents over time.

Methods: Data were derived from a population-based sample of male (N = 224) and female (N = 244) adolescents followed from grade 10 (M age = 15.5) to grade 11 (M age = 16.5). Peer networks were derived from best friend nominations. Self-reports were used to assess weapon carrying. Aggression and victimization were assessed using both self- and peer-reports. Use of dynamic social network modeling (SIENA) allowed prediction of weapon carrying in grade 11 as a function of weapon carrying of befriended peers, aggression, and victimization in grade 10, while selection processes and structural network effects (reciprocity and transitivity) were controlled for.

Results: Peer influence processes accounted for changes in weapon carrying over time. Self-reported victimization decreased weapon carrying 1 year later. Peer-reported victimization increased the likelihood of weapon carrying, particularly for highly aggressive adolescents. Boys were more likely to carry weapons than girls, but the processes associated with weapon carrying did not differ for boys and girls.

Conclusions: These findings revealed that, in this population-based sample, weapon carrying of best friends, as well as aggression, contributed to the proliferation of weapons in friendship networks, suggesting processes of peer contagion as well as individual vulnerability to weapon carrying.

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Weapon carrying by youth constitutes a serious threat to the lives and safety of others [1]. Compared with other Western countries, weapon carrying among adolescents is highest in the United States [2], and access to weapons is relatively easy. The question is, why do adolescents carry weapons? Multiple motivations may be involved [3], yet three explanations dominate research on weapon carrying. Weapon carrying among adoles-

cents has been explained as a consequence of peer influence [4], as a component of a delinquent lifestyle, and as a protective response to threats in the environment [5]. The goal of this study is to examine the relative contribution of each of these explanations in a normative population-based sample of male and female high school students in the United States.

Peer influence on weapon carrying has been inferred from the findings of previous research, showing that weapon carrying among adolescents is related to perceived weapon carrying of peers [6,7] or friends [4,8–10]. However, in these studies, the weapon carrying by friends was reported by adolescents themselves, which potentially inflates the magnitude of similarities in behaviors and, consequently, influences processes. Moreover, in

* Address for correspondence to: Jan Kornelis Dijkstra, ICS, University of Groningen, Grote Rozenstraat 31, 9712 TG Groningen, The Netherlands.

E-mail address: jan.dijkstra@rug.nl. (J.K. Dijkstra).

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most studies, cross-sectional designs were used that do not allow the exclusion of the possibility that similarity arises from weapon-carrying youth selecting one another as friends, that is, selection effects [11,12]. In a study of high-risk male adolescents, in which both mechanisms were untangled using longitudinal network data, similarities in weapon carrying were explained by peer influence processes rather than by selection [13]. In combination with the finding that weapon carriers tended to attract more friendship nominations over time, the authors concluded that adoption of friends' weapon carrying may be motivated by expected status enhancement [13].

There is reason to believe that peer influence dynamics related to weapon carrying may also exist in normative samples of adolescents. In adolescence, risk behaviors become more attractive, and spread easily via friendship networks [14]. Weapon carrying might be no exception to this rule. Even when the prevalence rates of weapon carrying are substantially lower than in high-risk samples, adolescents who carry a weapon might provide friends with access to weapons and motivate imitation of their weapon carrying, or even persuade others to carry weapons. When weapon carrying is not a visible practice in the wider peer group, close friendships might even be more important and salient for the proliferation of weapons among adolescents. Thus, even in a normative population-based sample, we expect that weapon carrying also proliferates in friendship networks through peer influence processes.

Alternatively, weapon carrying may emerge as part of a larger category of problem behaviors [3,15–20], particularly involvement in aggressive behaviors [16,19]. However, it has also been suggested that it is not so much being the initiator of aggression, rather it is being the target of aggression, that triggers weapon carrying as a defensive response [7,21]. Consistent with this perspective, weapon carrying has been associated with feelings of being threatened, such as victimization, fearfulness, and self-protection [7,21–24].

The latter two explanations may be interrelated: weapon carrying to enhance threats against others may increase the perceived need to carry weapons to deter or defend against potential retaliatory attacks; and weapon carrying for defensive purposes may embolden youth to take a more aggressive stance [23,25–27]. Weapon carrying may therefore emerge as a complex interaction between adolescents' status as an initiator of aggression and their experience as a victim of aggression.

Consistent with recent calls to place adolescent health behaviors in the context of peer social network dynamics [28,29], we tested the main effects of aggression, victimization, and peer influence, along with an interaction between aggression and victimization across a period of 1 year in the context of changing friendship patterns. We used longitudinal social network modeling (SIENA) to untangle these processes at the individual and peer environment levels, which may explain weapon-carrying behavior for boys and girls [30], while we controlled for friendship network dynamics that were unrelated to weapon carrying (e.g., reciprocity, transitivity) [31,32].

Methods

Participants and procedure

The participants were part of a longitudinal study on the social and academic development of children and youth. We used data across two consecutive high school years (grades 10

and 11) from a school in a mid-sized town in the northeastern United States. For 95% of all participants, information was available on best friend nominations as well as weapon carrying for at least one time point. These students were included in the current study, resulting in an analytical sample of 468 participants (boys: $N = 224$; girls: $N = 244$). The ethnic composition of this sample was 68.6% white, 15.8% African American, 10.9% Latino, 3.4% Asian American, .2% of other ethnic origin, and .9% missing. The school district in which the data were collected serves primarily lower and lower middle class families.

All testing took place in the spring, during the school year. Students were told that participation was voluntary and that any questions they did not wish to answer could be left blank. In addition to self-reports of behaviors, participants completed sociometric assessments each year. An alphabetic roster was created with the names of all students in the grade. Participants could name same- and cross-gender peers for all questions. This sociometric assessment was used to identify relationships among grade-mates (friendships), and aggression and victimization of peers (see later).

Measures

Best friends: We used best friend nominations (“Who are your best friends?”) to define peer networks. These nominations were summarized in adjacency matrices, indicating whether a best friend relation was absent (0) or present (1), with other members of the network. On average, students named 5.13 best friends in grade 10 and 4.90 in grade 11. In grade 10, 22% of the relations were reciprocal; in grade 11, 23% of the relations were reciprocal. The density of the network, representing the proportion of ties in relation to the total number of possible ties, was about .010 at both consecutive time points.

Weapon carrying was based on the question, “During the past 30 days, how many times did you carry a weapon, such as a gun, knife, or club?” Answer categories were 0 day, 1 day, 2 or 3 days, 4 or 5 days, and ≥ 6 days. Information about weapon carrying was available in both grades for 116 boys and 143 girls. Weapon carrying was stable for 80.2% of the boys, decreased for 7.8%, and increased for 12%. For girls, these percentages were 93% stable, 2.1% decreased, and 4.2% increased (Table 1).

Self-reported aggression and victimization were measured by asking participants to indicate how often they had different experiences with other students on a 5-point scale running from never to a few times a week. The aggression scale was based on three items: “I chased another student like I was really trying to hurt him or her,” “I threatened to hurt or beat up another student,” and “I hit, kicked, or pushed another teen in a mean way.” Answers to these items were summed, yielding a reliable scale ($\alpha = .84$). Victimization was based on the same items but worded to suit the victim of the aggression (e.g., “Another student chased me like he or she was really trying to hurt me”), yielding an internally consistent scale ($\alpha = .82$). Both scale scores were standardized z scores in the entire sample and were subsequently transformed to a 4-point scale, using increments of .5 of the continuous z score as the cut-off points (Table 2).

Peer-reported aggression and victimization were also used to include the perspective of peers. From the roster of grade-mates, respondents identified which students they believed “start fights,” “say mean things,” and “tease others.” Nominations that each participant received were summed to create an overall view of peer-reported aggression. The items “get hit,” “pushed,” or

Table 1
Percentage of participants carrying a weapon

Number of days of weapon carrying in previous 30 days	Boys		Girls	
	Grade 10 (N = 164)	Grade 11 (N = 174)	Grade 10 (N = 195)	Grade 11 (N = 192)
0	78.7 (129)	78.4 (138)	96.4 (188)	94.3 (181)
1	4.3 (7)	4.5 (8)	.0 (0)	1.6 (3)
2–3	4.3 (7)	4.5 (8)	2.6 (5)	1.0 (2)
4–5	1.2 (2)	1.7 (3)	.5 (1)	1.6 (3)
≥ 6	11.6 (19)	10.8 (19)	.5 (1)	1.6 (3)

Note: Total number of participants between parentheses.

“kicked by others” were used to measure peer-reported victimization. Again, the number of nominations received was counted for each student and z-standardized. For aggression, the z score was transformed to a 4-point scale in increments of .5. Because peer victimization was strongly centered on the mean, it was dichotomized to a 2-point scale indicating high versus low victimization. These four measures for aggression and victimization were measured at time 1 and used to predict weapon carrying at time 2 (Table 2).

Attrition analyses

We compared differences in weapon carrying, and differences in the aggression/victimization measures between respondents with missing weapon-carrying data and respondents with complete data. Adolescents with missing data on weapon carrying in grade 10 scored higher on weapon carrying in grade 11 than students with complete data ($t(366) = 2.23, p < .05; M = .56$ vs. .29). Respondents with missing data on weapon carrying in grade 11 reported significantly higher weapon carrying in grade 10 ($t(357) = 3.03, p < .01; M = .59$ vs. .24) and slightly higher self-reported victimization in grade 10 ($t(337) = 1.71, p = .09; M = 2.12$ vs. 1.87) than respondents with complete data in grades 10 and 11. No other differences were found.

Analysis strategy

The data were analyzed using SIENA. SIENA allows statistical estimation of a stochastic actor-based model for the coevolution of networks and behavior over time [31]. The model expresses that in response to the current network structure and attributes of the other network members, individuals can change a friendship tie (add or dissolve a tie), they can change their weapon-carrying behaviors (increase or decrease), or they can make no change to their friendships or behavior. Changes in behavior indicate influence effects; changes in network ties indicate selection effects.

Estimates are derived from iterative simulations within a Markov Chain Monte Carlo approach [31], yielding probabilities

of specific change patterns for individual behaviors and network relations given the observed data. The program estimates selection and influence effects while controlling each for the other, yielding estimates for changes in both networks and behavior [11,31,33]. Missing data are treated in SIENA in such a way that their influence on the estimation results is minimized. Specifically, the calculation of the target statistics is restricted to non-missing data [34].

Analyses in SIENA yield three types of parameters. First, the parameters of the network and behavior rate functions indicate the average number of opportunities for change in each. Second, network dynamics reflect changes in the friendship ties among network members. Structural network effects, such as reciprocity (the tendency to reciprocate friendship nominations) and transitivity (the tendency for friends of friends to become friends with each other), can produce changes in friendship patterns that are unrelated to the behavioral characteristics of the individuals involved. Three structural network effects were taken into account: (a) *density*, or the number of outgoing nominations; (b) *reciprocity*; and (c) *transitivity*. These structural network effects are important to take into account to avoid misspecifying estimates for selection and, consequently, influence [11]. For example, two adolescents with a common friend are likely to become friends as well (transitivity). When both adolescents are similar in weapon carrying, the attribution of their friendship to their similarity in weapon carrying would be inflated if the transitivity effect was not controlled for.

Three other types of network dynamic parameters, measuring selection effects, were estimated. *Activity* effects describe the extent to which a particular individual characteristic was associated with an actor making a friendship nomination. *Popularity* effects describe the extent to which a particular characteristic was associated with receiving more friendship nominations. Finally, *selection similarity* describes the extent to which youth select friends who are similar to themselves with regard to a particular characteristic. We estimated activity, popularity, and selection similarity effects with respect to both gender and weapon carrying.

Table 2
Descriptive statistics for aggression and victimization in grade 10

	Boys				Girls			
	Mean	SD	Range	N	Mean	SD	Range	N
Self-reported aggression	2.25	1.28	1–4	154	1.84	1.21	1–4	185
Self-reported victimization	2.16	1.30	1–4	154	1.75	1.11	1–4	185
Peer-reported aggression	2.31	.64	2–4	204	2.00	1.25	1–4	231
Peer-reported victimization	1.20	.40	1–2	204	1.26	.44	1–2	231

Table 3
Correlations between weapon carrying, aggression, and victimization

		1	2	3	4	5	6
1	Weapon-carrying grade 10	—	.47 ^a	.32 ^a	.11	.12	-.03
2	Weapon-carrying grade 11	.30 ^a	—	.30 ^a	.11	.11	-.11
3	Self-reported aggression grade 10	.27 ^a	.29 ^a	—	.70 ^a	.10	.05
4	Self-reported victimization grade 10	.22 ^a	.08	.70 ^a	—	-.02	.08
5	Peer-reported aggression grade 10	.03	.12	.19 ^a	.10	—	.12
6	Peer-reported victimization grade 10	-.06	.04	.03	.13	.15 ^a	—

Note: ^a $p < .05$. Correlations above the diagonal are for boys, below the diagonal for girls. Because categorical variables were used, correlations were calculated using Spearman's rho.

The third set of estimates is for parameters that predict changes to weapon carrying over time (behavior dynamics). The *weapon-carrying linear* effect indicates the overall tendency toward high or low values on weapon carrying. A negative parameter indicates that most respondents score below the mean on the weapon-carrying scale; a positive parameter indicates that the majority score above the mean. The *weapon-carrying quadratic* effect is a feedback effect of weapon carrying on itself [35]. A negative value would suggest a self-correcting mechanism; respondents with high values on weapon carrying are more likely to decrease their weapon carrying over time, whereas respondents with low values on weapon carrying are more likely to increase their weapon carrying (regression to the mean effect). Conversely, a positive effect indicates a self-reinforcing effect; low values of weapon carrying predict lower levels of weapon carrying, whereas high values of weapon carrying predict higher levels (polarization-effect).

The predictors of weapon carrying comprise the effects of gender, aggression, and victimization on changes in weapon carrying as well as the *peer influence effect*, which indicates the extent to which participants changed their weapon carrying in accordance with their friends' weapon carrying.

The test the distinct effects of *self-reported aggression* and *victimization* and of *peer-reported aggression* and *victimization* on weapon carrying, both were examined in two separate models. To examine the interplay between aggression and victimization, we also tested interactions between self-reported aggression and victimization, and between peer-reported aggression and victimization. The estimation of parameters is based on the methods of moments algorithm [36].

To facilitate interpretation of the results, we calculated the exponential function of the estimates (presented in text). For the effects that may explain similarities in friends' weapon carrying (i.e., selection and influence similarity), we first divided the estimates by the number of answer categories on the weapon-carrying scale minus one. Because of this, the odds ratios (ORs) for these effects reflect the effect of 1 U of increase or decrease on the weapon-carrying scale. The ORs for the covariates aggression and victimization were calculated in a similar way. Because the quadratic term was not linear, we did not calculate a corresponding OR.

Results

Correlations

Weapon carrying in grade 10 was related to weapon carrying 1 year later for boys and girls (Table 3). Self-reported aggression at time 1 was associated with weapon carrying in both grades for

boys and girls, whereas self-reported victimization was only related to weapon carrying at time 1 for girls. No associations were found between weapon carrying and peer-reported aggression or victimization. Self-reported aggression and victimization were equally correlated for boys and girls. Peer-reported aggression was only associated with peer-reported victimization and self-reported aggression for girls.

SIENA analyses

Table 4 shows the results of the SIENA analyses. Because the results of both models are largely similar, the findings are discussed simultaneously.

Table 4
Results from SIENA analyses

	Self-reported aggression and victimization		Peer-reported aggression and victimization	
	Est. ^a	SE	Est.	SE
Network dynamics^b				
Network rate function	21.85****	1.16	-21.17****	1.10
Predictors of friendship choices				
Structural network effects				
Density	-2.99****	.06	-3.02****	.04
Reciprocity	2.16****	.09	2.17****	.09
Transitivity	.43****	.02	.43****	.02
Gender effects^b				
Gender activity	-.11**	.05	-.11*	.06
Gender popularity	.18****	.05	.19****	.05
Same-gender selection	.32****	.06	.32****	.05
Weapon-carrying effects				
Weapon-carrying activity	.18**	.07	.14*	.08
Weapon-carrying popularity	.03	.08	.03	.08
Weapon-carrying selection	.43	.36	.39	.39
Behavior dynamics				
Weapon-carrying rate function	9.36****	2.59	8.68****	3.25
Predictors of weapon carrying				
Weapon-carrying linear	-1.20**	.47	-.95*	.54
Weapon-carrying quadratic	.68****	.13	.83****	.19
Gender ^c	.64*	.37	.32	.42
Peer influence ^d	12.05****	4.53	15.32**	6.09
Individual aggression	.68****	.18	.53**	.26
Individual victimization	-.41**	.18	-.54	.65

^a Odds ratios corresponding to these estimates are reported in the text.
^b The Jaccard index was .245, which indicates the relative stability of network ties between both time points.
^c Boys = 1.
^d Average similarity was used for the peer influence effect.
* $p < .10$.
** $p < .05$.
*** $p < .01$.
**** $p < .001$.

Predictors of friendship choices

The negative parameter for density indicates that participants were highly unlikely to nominate peers as friends arbitrarily, but rather based their choices on other factors, such as reciprocity and transitivity. Participants were almost nine times more likely to nominate as a friend a peer who also nominated them as a friend, compared with peers who did not nominate them as a friend (OR = 8.65 and OR = 8.73). The transitivity estimate reveals that friendships were more likely between respondents who shared a friend, compared with respondents who did not share friends (OR = 1.54).

The positive gender popularity effect means that boys received more nominations as best friend than girls (OR = 1.20), but the negative gender activity effect means that boys nominated fewer peers as best friends than did girls (OR = .89). The positive same-gender selection effect indicates that participants were more likely to select same-gender peers as friends than other-gender peers (OR = 1.38).

The significant weapon-carrying activity effect indicates that level of weapon carrying was positively associated with the number of grade-mates named as best friend. Specifically, an increase of 1 U on the weapon-carrying scale increased the probability of nominating versus not nominating peers as friends by a factor of 1.19 (or + 19%) and 1.15 (or + 15%), indicating higher social activity of weapon carriers. There was not a significant tendency for participants to select friends who were similar to themselves on levels of weapon carrying.

Predictors of weapon carrying

With regard to the behavior dynamics, the negative weapon-carrying linear effect indicates that most respondents scored below the midpoint on the weapon-carrying scale (OR = .30 and OR = .39). The positive quadratic effect indicates a self-reinforcing effect, reflecting that noncarriers tend to abstain from weapon carrying, whereas participants who already carried a weapon were more likely to increase their weapon carrying over time.

The results for gender showed that boys were somewhat more likely to increase their weapon carrying over time than girls only in the models with self-reported aggression and victimization. In both models, the average level of weapon carrying among peers named as best friends was a significant predictor for adolescent weapon carrying. Specifically, this peer influence effect showed that participants were 20 to 46 times more likely to make a move toward their friends' level of weapon carrying than not to change their weapon carrying. We also tested whether this influence effect differed for boys and girls, which was not the case (not presented here).

Self-reported aggression in grade 10 also predicted increased weapon carrying (OR = 1.26). However, self-reported victimization in grade 10 was associated with *decreased* weapon carrying (OR = .87). Peer-reported aggression predicted weapon carrying (OR = 1.19), whereas peer-reported victimization did not. No gender differences were found for the effects of aggression and victimization on weapon carrying (not presented here).

Finally, we tested the interaction effect between aggression and victimization on weapon carrying. It appeared that the effect of peer-reported aggression on weapon carrying buffered the effect of peer-reported victimization in such a way that high victimization increased the probability of

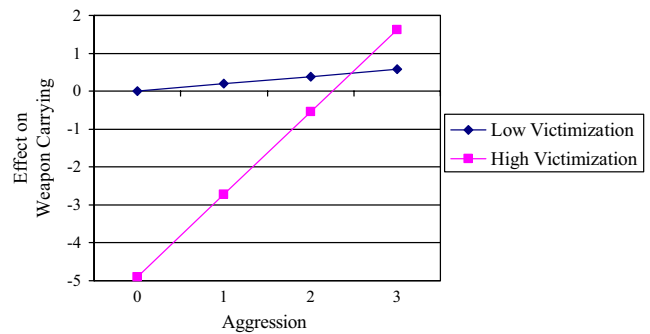


Figure 1. Interaction effect of peer-reported aggression and peer-reported victimization on weapon carrying.

weapon carrying only when aggression increased (Est.(SE) = 1.98 (.90), $p < .05$; Figure 1). No interaction effect was found for self-reported aggression and victimization.

Discussion

The findings of this study show that both having friends who carry weapons and being aggressive increase adolescents' weapon carrying 1 year later, revealing that both factors contribute to the proliferation of weapons among adolescents. The view that victimization spurs weapon carrying (e.g., for protection or retaliation) was rejected in this normative adolescent peer group. In fact, self-reported victimization generally decreased the likelihood of weapon carrying.

Although the findings of previous studies showed that indicators of victimization as well as aggression were associated with weapon carrying, studies in which both effects were tested simultaneously showed that associations of fear and victimization with weapon carrying were absent, contrary to the effects of aggression and delinquency [13,14,37]. This suggests that weapon carrying as a purely defensive response without engagement in problem behaviors may be uncommon. The finding that peer-reported victimization increased the likelihood of weapon carrying for highly aggressive adolescents underlines that experiences of victimization may prompt weapon carrying only among adolescents with a history of aggression [27].

A reason that we did not find this interaction effect for self-reported aggression and victimization might be the high collinearity between both measures, resulting in large standard errors. A more substantive explanation is that, similar to what has been found in the identification of bully-victims [38], peer reports seem better suited than self-reports to differentiate between aggressors, victims, and aggressor-victims, leading to more predictive validity in explaining changes in weapon carrying.

The fact that multiple processes involving peer experiences were related to weapon carrying underscores the extent to which adolescent health behaviors are embedded in complex, dynamic peer networks [28,29]. Together, these factors might create a dangerous mix that could result in weapon carrying among adolescents and, subsequently, weapon use. Tackling victimization and aggression in schools, and in particular how aggressive youth respond to victimization, and creating a safe environment for students seems, therefore, a good starting point for preventing adolescents from carrying weapons.

A limitation of our study is that adolescents with missing best friend or weapon-carrying data could not be included in the analyses. However, because adolescents with missing weapon-carrying data in grade 11 scored higher on weapon carrying in grade 10, effects might have been even more pronounced if there were no missing data [34].

Another weakness is that our measures of aggression and victimization pertained to experiences with other students at school, not taking into account aggression and victimization outside the school context. Also, we were unable to examine the extent to which gang membership played a role in changes in weapon carrying [39]. Within high-risk samples, weapon carrying is more common and might even be seen as accepted or expected [15], and high-risk adolescents are more prone to seek status enhancement in nonlegitimate ways in the absence of conventional means [40]. In a prior study of at-risk adolescents, it was found that weapon-carriers were significantly more popular among peers (attracted more friendship nominations over time), but made fewer friendship nominations [13]. This was not found in the current study, suggesting that status processes might be more pronounced among young high-risk adolescents.

The findings from this study that weapon carrying of best friends as well as aggression contributed to the proliferation of weapons in friendship networks, provide support for continuing to explore the complex interplay between experiences in the peer context and weapon carrying among adolescents.

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