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Dynamics of adolescent friendship networks and smoking behavior: Social network analyses in six European countries☆

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ABSTRACT

The co-evolution of adolescents' friendship networks and their smoking behavior is examined in a large sample across six European countries. Selection and influence processes are disentangled using new methods of social network analysis that enable alternative selection mechanisms to be controlled for. The sample consisted of 7704 adolescents participating in the control group of the ESFA (European Smoking prevention Framework Approach) study. The design was longitudinal with four observations. The main measurements were friendship ties, adolescents smoking behavior, parental smoking behavior, and sibling smoking behavior. Results indicated that in each country adolescents preferred selecting friends based on similar smoking behavior. Support for the influence of friends was found in only two countries. A similarity in smoking behavior between friends was explained more strongly by smoking-based selection processes than by the influence of friends in each of the six countries. Prevention programs need to address aspects that drive peer selection, and reinforce non-smoking attitudes in adolescents.

Introduction

Although smoking prevention programs yield short-term effects, the long-term effectiveness is often modest (Flay, 1985; Peterson, Kealy, Mann, Marek, & Sarason, 2000; US Department of Health and Human Services, 1994). One explanation may be that the assumption that smoking onset is caused by peer influences (Evans, Dratt, Raines, & Rosenberg, 1988; Flay, 1985) is only partly valid. Although smoking behavior tends to be similar among friends (Bauman, Fisher, Bryan, & Chenoweth, 1984; Ennett, Bauman, & Koch, 1994; Sussman et al., 1990), this similarity can also be attributed to the selection of similar others, instead of influence (Cohen, 1977; De Vries, Candel, Engels, & Mercken, 2006; Ennett & Bauman, 1994; Fisher & Bauman, 1988; Kandel, Kessler, & Margulies, 1978; Mercken, Candel, Willems, & De Vries, 2007).

Although previous studies of peer influence on smoking onset successfully controlled for other determinants of smoking, such as age, gender, parental and sibling smoking (Avenevoli & Merikangas, 2003), they failed to control for other determinants of friendship selection besides smoking-based selection of friends. Some of these other determinants are reciprocation of friendship; becoming a friend of somebody who already is a friend of a friend (Burk, Steglich, & Snijders, 2007; Snijders & Baerveldt, 2003); and similarities in other variables besides smoking behavior such as alcohol consumption (Steglich, Snijders, & West, 2006), age, ethnicity, education, or gender (McPherson, Smith-Lovin, & Cook, 2001). All of these other determinants may also lead to similarity of friends with respect to smoking behavior, and failing to control for such alternative selection processes may accordingly result in an overestimation of selection based on similar smoking behavior.

Furthermore, previous studies did not account for unobserved changes in friendships and smoking behavior between the measurement moments. Longitudinal data is mostly gathered at discrete moments, which makes it impossible to unequivocally identify which process is responsible for a network or behavioral change. In between two observations, changes will occur in friendship and smoking behavior, and a change may even be

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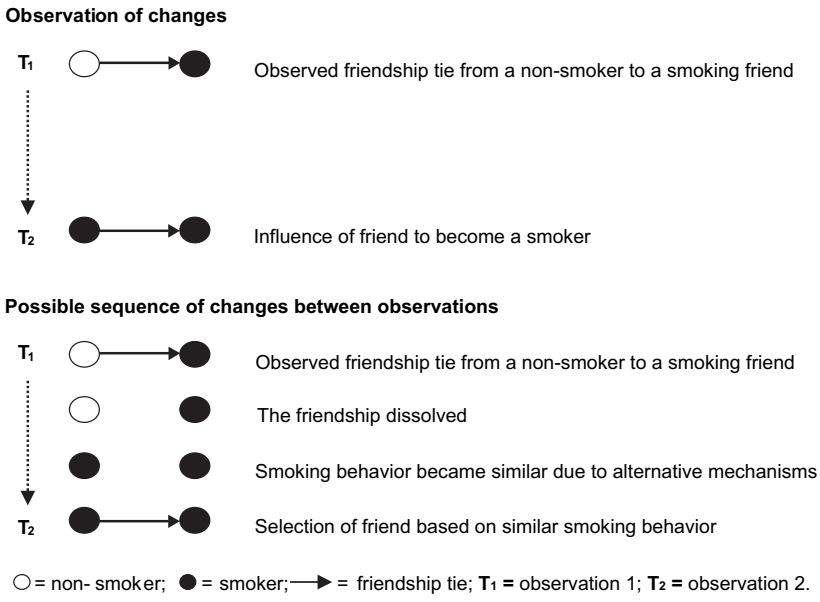

Fig. 1. Ambiguity in diagnosing the peer influence process.

followed by a change back to the original value before the next observation. Fig. 1 demonstrates a process diagnosed as influence on the basis of discrete observations, but for which the sequence of events could have been different, up to the point that it could have been a case of selection based on similar smoking behavior when observed continuously.

This study examined smoking-related friendship selection and friends' influence within the same school grade, while controlling for alternative selection mechanisms. Although data were gathered at four discrete moments in time, continuous changes in friendships and smoking behavior in between two observations were modeled using newly developed methods of social network analysis (Snijders, Steglich, & Schweinberger, 2007; Steglich et al., 2006). These methods employ a more complete representation of repeated measures data on friendship networks and smoking behavior, and allow the parameters that influence selection processes to be estimated and controlled for. The sample included adolescents across six countries in Northern, Central, and Southern Europe, permitting better generalization than data from just one country. Based on previous studies we hypothesized that similarities in smoking behavior among friends within the same school grade would be attributed to both selection and influence processes. We furthermore expected stronger selection processes than peer influence processes to explain the observed similarity of smoking behavior between friends.

Methods

Participants

The sample consisted of 7704 adolescents from six European countries (Denmark, Finland, the Netherlands, Portugal, the United Kingdom (UK), and Spain) that participated in the European Smoking prevention Framework Approach (ESFA) study (De Vries et al., 2003). Communities (or regions) were randomly selected in each country. High schools were asked to participate, with a 50% chance of becoming an experimental school. Experimental schools were excluded from the current study because the intervention may have changed the relationship between variables of interest. This study included all control schools that participated at the four measurement times: 17 Danish schools ($N = 843$), 11 Finnish schools ($N = 1326$), 9 Dutch schools ($N = 2524$), 8 Portuguese schools ($N = 1590$), 4 UK schools ($N = 792$), and 21 Spanish schools ($N = 629$). In none of the countries did school transitions occur during the ESFA project. Table 1 demonstrates the average school network structure and demographic characteristics. The average number of friends decreased slightly over time, while smoking behavior increased.

Procedure

Self-administered questionnaires were distributed in the seventh grade (mean age = 13) of each participating school during autumn 1998. Follow-up was conducted at 12, 24, and 30 months (De Vries, Dijk, et al., 2006). Parents were informed about the ESFA study and could refuse to have their child participate. All students present on the days of data collection were asked to complete the questionnaire. Adolescents were informed that responses would be treated confidentially and that they too could refuse to participate. Students returned their questionnaires in sealed envelopes to guarantee confidentiality. The overall percentage of refusals to participate was 1.7 (0.6% in Denmark, 3.0% in Finland, 0.6% in the Netherlands, 2.2% in Portugal, 1.0% in Spain, and 2.3% in the UK).

Questionnaire

Friendship ties were assessed by one question in which adolescents could name up to five best friends inside and/or outside school (McCallister & Fisher, 1978). Only best friends inside the same school grade were included here, since only best friends also participated as respondents and filled out the questionnaire.

Smoking behavior of adolescents was assessed by one question based on previous research on smoking behavior (Crone et al., 2003; De Vries, Dijkstra, & Kuhlman, 1988; Dijkstra, Mesters, De Vries, van Breukelen, & Parcel, 1999): "On average, how many cigarettes do you smoke during a week (also count the weekend)?" (0 = 0, 1 = between 0 and 1, 2 = 1–10, 3 = 11–30, 4 = >30).

Parental smoking behavior was measured by two questions: 'Does your father (male caregiver) smoke?' and 'Does your mother

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Table 1
Descriptive statistics of network structure of schools and individual characteristics.

Country	DK ($N=843$)	FN ($N=1326$)	NL ($N=2524$)	PO ($N=1590$)	UK ($N=792$)	SP ($N=629$)
Average network structure of schools						
Average number of adolescents	50	121	280	199	198	30
Average number of joiners						
Period 1	7	8	24	30	27	4
Period 2	4	9	36	25	7	2
Period 3	3	2	10	5	9	0
Average number of leavers						
Period 1	4	8	14	38	15	2
Period 2	8	10	43	39	25	4
Period 3	7	20	22	14	33	2
Average number of friendship nominations						
Wave 1	2.4	1.7	1.5	1.4	2.1	2.2
Wave 2	2.3	2.0	1.7	1.5	2.7	2.2
Wave 3	2.2	1.8	1.7	1.5	2.6	2.0
Wave 4	2.2	1.8	1.6	1.5	2.3	1.8
Average observed network autocorrelation/similarity[a]						
Wave 1	0.2	0.4	0.2	0.1	0.1	0.0
Wave 2	0.4	0.4	0.3	0.4	0.3	0.3
Wave 3	0.5	0.4	0.3	0.2	0.5	0.2
Wave 4	0.3	0.4	0.3	0.3	0.4	0.3
Individual characteristics						
Smoking behavior adolescent						
Wave 1	0.4	0.5	0.2	0.2	0.2	0.1
Wave 2	0.8	0.9	0.5	0.4	0.6	0.5
Wave 3	1.1	1.4	0.8	0.6	0.9	0.8
Wave 4	1.2	1.4	0.9	0.7	1.0	1.2
Alcohol consumption adolescent (0–3)	0.3	0.3	0.3	0.2	0.5	0.1
Age at baseline (in years)	13.3	13.4	12.8	13.2	12.6	12.4
Percentage females	50.0	47.0	49.0	47.0	64.0	47.0
Percentage Natives	97.0	–	75.0	87.0	98.0	95.0
School achievement (1–3)	2.3	2.0	–	2.2	2.2	2.1
Percentage at least one smoking parents	63.7	49.9	50.2	51.4	38.0	63.2
Percentage at least one smoking siblings	25.8	23.0	19.3	19.0	18.5	23.3

Note. DK = Denmark, FN = Finland, NL = the Netherlands, PO = Portugal, UK = United Kingdom and SP = Spain; N = total number of adolescents participating in at least one wave in the school networks. Smoking behavior is coded: 0 = 0 cigarettes each week; 1 = between 0 and 1; 2 = 1–10; 3 = 11–30; 4 = >30; Alcohol consumption is coded: 0 = 0 glasses alcohol each week; 1 = 1–2; 2 = 3–5; 3 = >5; School achievement is coded: 1 = among the lower third of the class; 2 = middle third; 3 = best third. – = variable was not measured.

[a] Network autocorrelation coefficient: Moran's I.

(female caregiver) smoke?', and was recoded into one variable (0 = neither smokes, 1 = at least one parent (caregiver) smokes).

Sibling smoking behavior was measured by two questions: 'Does one or more of your brother(s) smoke?' and 'Does one or more of your sister(s) smoke?', and was recoded into one variable (0 = no siblings smoke, 1 = at least one sibling smokes). For those adolescents who indicated having no siblings, the answer was treated as missing.

Alcohol consumption (0 = 0 glasses of alcoholic drinks per week, 1 = 1 or 2 glasses, 2 = 3–5 glasses, 3 = more than 5 glasses), age (in years), gender (0 = boy, 1 = girl), nationality (0 = non-native, 1 = native), and self-reported school achievement (1 = among the lower third of the class, 2 = the middle third, 3 = the highest third) were also recorded.

Ethical approval was obtained from the research institute Caphri, Maastricht University. A letter was sent to the head of every school, who then informed the parents or caregivers. Only general data about the survey was provided to ensure confidentiality.

Model development

The interdependence across individuals of changes in friendship ties, and the interdependence of changes in friendships and in smoking behavior, requires a model that expresses this dependence in a plausible way. To examine selection and influence a model was constructed which consists of two parts: one part modeled friendship network changes (selection processes), another part modeled smoking behavior changes (influence processes). The combined model examined selection and influence processes simultaneously while controlling either process for the other one. Continuous-time Markov chains were used to model continuous changes between discrete observations. This implies that changes in friendship choices or smoking behavior were assumed to depend on the current state of friendship and smoking, not on the more distant past (Markov property). The mathematical specification and statistical estimation procedures are given by Snijders et al. (Snijders, 2001; Snijders, Steglich C., et al., 2007) and the model specification was as follows.

Friendship network changes: selection processes

The friendship network evolution part of the model included functions of current network structure and adolescents' attributes that determine friendship choice probabilities. These were called 'effects' and are presented in the upper part of Table 2. This list contained three smoking-based friendship selection components: the effect of smoking behavior on number of friends chosen (smoking behavior adolescent), the effect of potential friends' smoking behavior (smoking behavior potential friend), and the interaction effect between these two, which was used to test whether adolescents who smoke more also prefer friends who smoke more (smoking behavior adolescent × potential friend). As friendship choices might depend on characteristics of the current network (McPherson et al., 2001; Snijders, 2001; Van de Bunt, Van Duijn, & Snijders, 1999), the effects of number of friends chosen

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Table 2
Included effects for modeling selection and influence processes simultaneously.

Friendship network change: selection	**Description**
Smoking behavior adolescent	Main effect of the adolescent's own smoking behavior on selection of friends
Smoking behavior potential friend	Main effect of potential friends' smoking behavior on selection of friends
Smoking behavior adolescent × potential friend	Preference for choosing a friend based on similar smoking behavior
Outdegree	General preference for choosing a friend
Reciprocity	Preference to choose those who have already chosen the adolescent as a friend
Transitivity	Preference for being a friend of a friends' friend
Alcohol consumption adolescent	Main effect of the adolescent's own alcohol consumption on selection of friends
Alcohol consumption potential friend	Main effect of potential friends' alcohol consumption on selection of friends
Alcohol consumption adolescent × potential friend	Preference for choosing a friend based on similar alcohol consumption
Age adolescent	Main effect of the adolescent's own age on selection of friends
Age potential friend	Main effect of potential friends' age on selection of friends
Age adolescent × potential friend	Preference for choosing a friend based on similar age
Gender adolescent	Main effect of the adolescent's own gender on selection of friends
Gender potential friend	Main effect of potential friends' gender on selection of friends
Gender adolescent × potential friend	Preference for choosing a friend based on similar gender
Nationality adolescent	Main effect of the adolescent's own nationality on selection of friends
Nationality potential friend	Main effect of potential friends' nationality on selection of friends
Nationality adolescent × potential friend	Preference for choosing a friend based on similar nationality
School achievement adolescent	Main effect of the adolescent's own school achievement on selection of friends
School achievement potential friend	Main effect of potential friends' school achievement on selection of friends
School achievement adolescent × potential friend	Preference for choosing a friend based on similar school achievement
Smoking behavior change: influence	**Description**
Smoking behavior friend	Main effect of friend's smoking behavior on his own smoking behavior
Incoming friendships (popularity)	Main effect of adolescents' number of nomination by others on his own smoking behavior
Outgoing friendships	Main effect of adolescents' number of nominated friends on his own smoking behavior
Tendency to smoke	General preference to smoke
Addiction to smoke	Feedback effect of adolescent's own smoking behavior on itself
Smoking behavior parents	Main effect of parental smoking behavior on his own smoking behavior
Smoking behavior siblings	Main effect of siblings' smoking behavior on his own smoking behavior
Alcohol consumption adolescent	Main effect of an adolescent's alcohol consumption on his own smoking behavior
Age adolescent	Main effect of an adolescent's age on his own smoking behavior
Gender adolescent	Main effect of an adolescent's gender on his own smoking behavior
Nationality adolescent	Main effect of an adolescent's nationality on his own smoking behavior
School achievement adolescent	Main effect of an adolescent's school achievement on his own smoking behavior

(outdegree), number of reciprocal friends chosen (reciprocity), and number of friends chosen who were also a friend of a friend (transitivity) were included. Furthermore, selection based on alcohol consumption, age, gender, nationality, and school achievement of adolescents and potential friends was controlled for (see Table 2 for a complete overview).

Smoking behavior changes: influence processes

The smoking behavior evolution part of the model included a list of functions of network, smoking behavior, and other attributes on which probabilities of changes in smoking behavior may depend. These effects are presented in the lower part of Table 2. The list contained three friendship network-related influence components: the effect of smoking behavior of friends on adolescent smoking; the effect of number of received friendship nominations (incoming friendships/popularity), and the effect of number of outgoing friendship nominations on smoking (outgoing friendships). Included control effects were the tendency to smoke, the addictive ('feedback') effect of smoking, parental and sibling smoking, and adolescents' alcohol consumption, age, gender, nationality, and school achievement. Adequately controlling for attributes resulted in a larger number of effects included in the friendship evolution part of the model compared to the smoking behavior evolution part. This difference was due to the multidimensional nature of selection processes. For example, while the effect of gender on adolescent smoking can be modeled by one influence parameter (the effect of adolescents' gender on own smoking behavior), the effect of gender on friendship can be modeled by three different selection features: the gender of the adolescent, the gender of the potential friend, and the similarity in gender of the adolescent and the potential friend.

Analysis

The proposed combined model was analyzed for each school separately using SIENA (Simulation Investigation for Empirical Network Analysis) software (Snijders, Steglich, Schweinberger, & Huisman, 2007). Effects were tested on the basis of *t*-ratios defined as estimate divided by standard error, with an approximate standard normal null distribution (Snijders, 2001). All respondents were included in the network and data were corrected for respondents who entered the study at a later time point or left the study at an earlier time point (Huisman & Snijders, 2003). Estimations were made using the Method of Moments, and for the Spanish schools, because of the small networks, by Maximum Likelihood (Snijders, Steglish C. E. G., et al., 2007) with the usual convergence criteria. When analyzing small datasets in combination with complex models, the Maximum Likelihood method is preferred above the Method of Moments as it tends to be a more efficient estimation method in the sense of producing estimates with smaller standard errors. When analyzing larger datasets the efficiency advantage is negligible and there is no reason not to use the less time-consuming Method of Moments (Snijders, Steglich C. E. G., et al., 2007).

Finally, for each country, results of all school network analyses were combined in a meta-analysis. The null hypotheses that in all schools a nonpositive effect (right one-sided test) was present, and that in all schools a nonnegative effect (left one-sided test) was present, were separately tested for using Fisher's combination of one-sided tests (Hedges & Olkin, 1985). To control for multiple (right and left) testing, there was deemed to be significant support for an effect if either of these combination tests was significant at level 0.025. The null hypothesis that effect parameters were constant across schools was tested by the method of Cochran

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adapted for network dynamics by Snijders and Baerveldt (Cochran, 1954; Snijders & Baerveldt, 2003).

The relative contribution of selection, influence, and alternative mechanisms to observed smoking behavior similarity

A descriptive statistic measuring the similarity of individuals linked in a network is Moran's I, a spatial autocorrelation coefficient (Cliff & Ord, 1981) applied to adjacency in the network. By calculating the average network autocorrelation in networks simulated according to models with coefficients estimated under five different specifications, the contributions of each specification to observed smoking similarity between friends can be expressed, as described in (Steglich, Snijders, & Pearson, submitted for publication). For these analyses, only schools with a mean observed autocorrelation of at least 0.1 were included, thereby excluding 5 Danish and 4 Spanish schools. The first model specification was a baseline trend model based on the initially observed network and smoking data. The second model was a control model including all control variables but excluding smoking-based selection and the influence of friendship networks. The third model was the second model to which all smoking-based selection effects are added, while the fourth model was the second model extended by all influence effects. Finally, the fifth model included all effects as reported in Table 2. Average network autocorrelations, based on a large number of simulations, were expected to be lowest in the first and second models, intermediate in the third and fourth, and highest in the fifth model. The relative increase, going from the second model to the third or fourth model, compared with the increase from the second model to the fifth, indicates the proportion of network autocorrelation that can be allocated to smoking-based selection or influence friendship networks respectively. Network autocorrelations were averaged across schools to obtain an overall conclusion per country.

Results

Friendship network changes: selection of friends

The results of the first part of the model, examining effects on which friendship selection depended, are depicted in Table 3. In all six countries, adolescents who smoked more had a greater tendency to choose friends who likewise scored high on smoking behavior, as indicated by the significant interaction effect of smoking behavior adolescent × potential friend.

The results for the included alternative selection mechanisms revealed that adolescents significantly preferred not to select arbitrary friends, but preferred to have reciprocal friendships and to be friends with their friends' friends, as indicated by the significant negative outdegree effects, and significant positive reciprocity and transitivity effects. Adolescents did not select friends based on similar alcohol consumption. However, only in Spain adolescents were more popular (more often selected as a friend) when they drank more alcohol, as indicated by the significant effect 'alcohol consumption of potential friend'. Friends were selected based on similar age in the Netherlands, Portugal, and Spain. In Denmark, the younger the adolescents were, the more they were selected as friends and selected friends themselves. Adolescents tended to select friends based on similar gender in all countries. Selection based on similar nationality was found only in the Netherlands, although non-native Portuguese adolescents selected fewer friends themselves but were more often selected as friends compared to native Portuguese adolescents. In the UK and Spain, adolescents selected friends based on similar school achievement.

Smoking behavior changes: influence processes

The results of the smoking behavior evolution part of the model are reported in Table 4. Only in Finland and the Netherlands was adolescent's smoking behavior influenced by friends' smoking behavior. Being more often nominated as a friend (popularity) or nominating more friends did not have an impact on own smoking behavior as indicated by no significant effects due to incoming friendships and outgoing friendships.

In all countries, the significant effects of the control variables 'tendency to smoke' and 'addiction to smoke' implied that adolescents had an overall tendency not to smoke, but smoking behavior was self-reinforcing due to its addictive nature. In the Netherlands and Portugal, adolescents with at least one smoking parent had a higher tendency to smoke. In the Dutch sample, adolescents also smoked more when at least one of their siblings smoked. Drinking more alcohol resulted in more smoking in the Netherlands and the UK. The tendency to smoke increased with age only in Portugal. In Portugal, the UK, and Spain, girls smoked more than boys. Non-native Spanish adolescents (those adolescents with a South American, Mediterranean, Asian or other background) had a higher tendency to smoke compared to native Spanish adolescents. Adolescents with lower school achievement had a higher tendency to smoke in Denmark and Spain.

The relative contribution of selection and influence processes to smoking behavior similarities

The contribution of the various mechanisms generating similarities in smoking behavior among friends is depicted in Fig. 2. The slices labeled 'selection' represent the proportion of similarity attributed to smoking-based friendship selection processes. The mean values of this proportion were 32% in Finland, 19% in Denmark, 45% in the Netherlands, 27% in Portugal, 17% in the UK, and 47% in Spain.

The slices labeled 'influence' reflect the proportion of similarity attributed to influence from adolescents' friendship networks (smoking behavior of friends, and numbers of given and received friendship nominations). These proportions were 19% in Finland, 10% in Denmark, 23% in the Netherlands, 13% in Portugal, 7% in the UK, and 6% in Spain.

All selection and influence mechanisms except for smoking-based selection and influence of friends are jointly represented by the slices labeled 'control'. These proportions ranged from 1% in Portugal to 38% in Spain. Finally, the slices labeled 'trend' cover the consequences of the similarity observed in the preceding wave. The proportions of smoking behavior similarity explainable from the previous wave range from 9% in Spain to 49% in Portugal.

In all countries the proportion of similarity in smoking behavior explained by smoking-based selection was higher than the proportion due to influence of adolescents' friendship network. A rather large proportion was explained by alternative selection and influence processes, and general trends we controlled for.

Discussion

This study aimed to disentangle influence and selection by examining the co-evolution of adolescents' friendship networks and smoking behavior in six European countries, using newly developed social network analysis techniques.

Our findings clearly demonstrate that selection processes play an important role in creating smoking behavior similarity within friendships. Adolescents preferred to select friends with similar smoking behavior in each country. These results support previous findings about the importance of selection processes (Cohen, 1977;

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Table 3
Meta analyses results per country: estimates, standard errors, p-values and differences between schools of the network evolution part of the model.

Country	DK ($N = 843$)				FN ($N = 1326$)				NL ($N = 2524$)				PO ($N = 1590$)				UK ($N = 792$)				SP ($N = 629$)			
	b	s.e.	*p*-values		B	s.e.	*p*-values		B	s.e.	*p*-values		b	s.e.	*p*-values		B	s.e.	*p*-values		b	s.e.	*p*-values	
			left	right			left	right			left	right			left	right			left	right			left	right
Friendship network change: selection																								
Smoking behavior A	–0.06	0.03	0.23	0.72	–0.04	0.02	0.05	0.94	**–0.06**	0.02	0.00	1.00	0.02	0.06	0.45	0.29	–0.03	0.04	0.13	0.58	–0.04	0.03	0.12	0.99
Smoking behavior PF	**0.02°**	0.08	0.38	0.00	–0.01	0.02	0.29	0.85	0.02	0.02	0.77	0.15	–0.04	0.04	0.15	0.88	–0.02	0.03	0.26	0.88	**0.02**	0.06	0.25	0.00
Smoking behavior A × PF	**0.05**	0.02	0.95	0.01	**0.06**	0.01	1.00	0.00	**0.07**	0.01	1.00	0.00	**0.10**	0.03	1.00	0.00	**0.07**	0.02	0.57	0.00	**0.10**	0.02	1.00	0.00
Outdegree	**–2.49°**	0.14	0.00	1.00	**–3.32**	0.05	0.00	1.00	**–3.38°**	0.05	0.00	1.00	**–3.05°**	0.15	0.00	1.00	**–3.14°**	0.17	0.00	1.00	**–2.10**	0.05	0.00	1.00
Reciprocity	**1.46**	0.10	1.00	0.00	**1.56°**	0.14	1.00	0.00	**2.25°**	0.04	1.00	0.00	**1.42**	0.09	1.00	0.00	**1.23**	0.12	1.00	0.00	**0.96**	0.06	1.00	0.00
Transitivity	**0.93**	0.05	1.00	0.00	**1.18**	0.05	1.00	0.00	**1.26°**	0.06	1.00	0.00	**1.39°**	0.06	1.00	0.00	**1.57**	0.10	1.00	0.00	**0.70°**	0.06	1.00	0.00
Alcohol consumption A	–0.00	0.11	0.35	0.50	–0.03	0.04	0.21	0.85	–0.04	0.03	0.08	0.94	–0.08	0.07	0.04	0.97	–0.03	0.03	0.22	0.83	–0.15	0.24	0.15	0.81
Alcohol consumption PF	0.03	0.07	0.52	0.17	0.02	0.03	0.74	0.30	0.04	0.02	1.00	0.13	0.07	0.05	0.68	0.16	–0.02	0.03	0.22	0.86	**0.31**	0.08	1.00	0.00
Alcohol consumption A × PF	0.13	0.06	0.96	0.21	0.07	0.04	0.98	0.05	0.05	0.03	0.54	0.07	0.13	0.06	0.48	0.13	0.01	0.06	0.34	0.11	0.06	0.09	0.70	0.39
Age A	**–0.19°**	0.17	0.01	0.84	–0.15	0.07	0.07	0.98	**0.06**	0.02	0.98	0.02	–0.02	0.05	0.20	0.41	0.00	0.05	0.66	0.62	–0.09	0.08	0.10	0.96
Age PF	**–0.15**	0.10	0.02	0.94	–0.06	0.08	0.13	0.91	**–0.03**	0.02	0.02	0.98	**–0.09**	0.03	0.00	1.00	–0.04	0.05	0.08	0.78	**–0.26**	0.16	0.00	0.95
Age A × PF	0.15	0.17	0.89	0.20	0.07	0.31	0.82	0.38	**0.08**	0.03	0.99	0.00	**0.09°**	0.03	0.95	0.00	–0.03	0.08	0.43	0.76	**0.58**	0.32	0.97	0.01
Gender A	0.01	0.13	0.32	0.52	0.03	0.15	0.56	0.25	**–0.08**	0.04	0.02	0.88	–0.05	0.07	0.52	0.88	**–0.26**	0.08	0.00	1.00	–0.11	0.08	0.08	0.89
Gender PF	0.01	0.07	0.53	0.63	–0.15	0.09	0.06	0.96	**0.09**	0.04	0.98	0.01	–0.04	0.06	0.33	0.93	**0.24**	0.17	0.99	0.01	0.11	0.09	0.90	0.08
Gender A × PF	**2.14°**	0.31	1.00	0.00	**3.22°**	0.22	1.00	0.00	**2.31°**	0.11	1.00	0.00	**2.07**	0.38	1.00	0.00	**2.59°**	0.47	1.00	0.00	**1.36°**	0.14	1.00	0.00
Nationality A	0.06	0.36	0.67	0.51	–		–	–	–0.04	0.03	0.10	0.96	**–0.33**	0.12	0.01	0.99	0.06	0.15	0.71	0.39	–0.01	0.25	0.65	0.64
Nationality PF	–0.04°	0.54	0.23	0.17	–		–	–	0.06	0.05	0.95	0.03	**0.25**	0.08	0.80	0.01	–0.01	0.27	0.41	0.46	–0.30	0.39	0.07	0.67
Nationality A × PF	0.99	0.69	0.87	0.19	–		–	–	**0.42°**	0.12	1.00	0.00	0.03	0.35	0.82	0.67	–2.02	3.06	–	–	–1.63	2.28	0.26	0.76
School achievement A	–0.06	0.09	0.14	0.81	0.03	0.03	0.89	0.33	–	–	–	–	–0.01	0.05	0.78	0.67	0.02	0.06	0.43	0.14	–0.01	0.05	0.40	0.70
School achievement PF	0.05°	0.12	0.42	0.05	–0.03	0.03	0.06	0.60	–	–	–	–	–0.03	0.09	0.06	0.19	–0.02	0.03	0.40	0.85	**0.07**	0.07	0.73	0.02
School achievement A × PF	0.18	0.08	0.87	0.06	0.02	0.03	0.73	0.38	–	–	–	–	0.21	0.08	0.99	0.04	**0.33**	0.05	1.00	0.00	**0.16**	0.08	0.89	0.01

Note. DK = Denmark, FN = Finland, NL = the Netherlands, PO = Portugal, UK = United Kingdom and SP = Spain; *N* = number of adolescents; b = unstandardized coefficients according to the Snijders–Baerveldt method (2003); s.e. = standard error; *p*-values: Fisher's combination of one-sided tests; Bold values represent significant results; °Significant differences found between schools according to the Snijders–Baerveldt method (2003). – = not measured.

Table 4
Meta analyses results per country: estimates, standard errors, p-values and differences between schools of the influence evolution part of the model.

Country	DK (N = 843)				FN (N = 1326)				NL (N = 2524)				PO (N = 1590)				UK (N = 792)				SP (N = 629)			
	b	s.e.	*p*-values		b	s.e.	*p*-values		b	s.e.	*p*-values		b	s.e.	*p*-values		b	s.e	*p*-values		b	s.e	*p*-values	
			left	right			left	right			left	right			left	right			left	right			left	right
Smoking behavior change: influence																								
Smoking behavior friend	0.32	0.17	0.91	0.12	**0.21**	0.08	0.99	0.01	**0.26**	0.08	1.00	0.01	0.18	0.28	0.71	0.39	−0.27	0.29	0.33	0.73	0.19	0.30	0.66	0.09
Incoming friendships	0.05	0.09	0.44	0.67	−0.03	0.04	0.37	0.89	0.01	0.05	0.76	0.40	−0.10	0.11	0.15	0.89	−0.04	0.05	0.39	0.85	0.03	0.06	0.24	0.23
Outgoing friendships	0.08	0.09	0.79	0.47	−0.02	0.05	0.31	0.79	0.01	0.06	0.47	0.70	−0.03	0.13	0.31	0.70	−0.12	0.09	0.16	0.89	−0.17	0.12	0.04	0.91
Tendency to smoke	**−1.22**	0.24	0.00	1.00	**−0.71**	0.07	0.00	1.00	**−1.77**	0.12	0.00	1.00	**−1.62**°	0.30	0.00	1.00	**−0.97**	0.42	0.00	1.00	**−0.28**	0.27	0.02	0.76
Addiction to smoke	**0.42**	0.06	1.00	0.00	**0.49**	0.02	1.00	0.00	**0.57**	0.02	1.00	0.00	**0.54**	0.04	1.00	0.00	**0.55**	0.07	1.00	0.00	**0.50**	0.16	1.00	0.00
Parental smoking	0.05	0.39	0.56	0.21	**0.25**	0.05	1.00	0.00	**0.20**	0.10	1.00	0.00	**0.41**	0.22	0.99	0.00	0.15	0.14	0.65	0.22	0.34	0.19	0.98	0.09
Sibling smoking	0.34	0.18	0.89	0.05	0.13	006	0.97	0.05	**0.32**	0.07	1.00	0.00	0.15	0.23	0.75	0.12	0.13	0.14	0.86	0.24	0.28	0.19	0.99	0.04
Alcohol consumption A	0.27	0.13	0.81	0.18	0.03	0.06	0.41	0.30	**0.10**	0.07	0.75	0.01	0.21	0.09	0.38	0.05	**0.34**	0.11	0.96	0.00	−0.14	1.00	0.18	0.18
Age A	−0.08	0.25	0.53	0.68	−0.03	0.07	0.17	0.71	−0.07	0.05	0.28	0.95	**0.11**	0.05	0.99	0.02	0.14	0.12	0.98	0.14	0.18	0.32	0.95	0.13
Gender A	0.02	0.16	0.42	0.63	0.06	0.07	0.90	0.17	0.02	0.05	0.60	0.55	**0.37**	0.27	1.00	0.01	**0.33**	0.13	0.97	0.02	**0.33**	0.19	0.99	0.01
Nationality A	0.32	0.49	0.88	0.34	–		–	–	0.09	0.07	0.83	0.13	0.16	0.23	0.88	0.18	−0.95	0.61	0.09	0.97	**2.86**	1.31	0.98	0.02
School achievement A	**−0.39**	0.15	0.01	0.98	−0.03	0.03	0.13	0.72	–	–	–	–	−0.22	0.10	0.11	0.93	−0.14	0.10	0.05	0.98	**−0.55**	0.33	0.00	0.98

Note. DK = Denmark, FN = Finland, NL = the Netherlands, PO = Portugal, UK = United Kingdom and SP = Spain; *N* = number of adolescents; b = unstandardized coefficients according to the Snijders–Baerveldt method (2003); s.e. = standard error; *p*-values: Fisher's combination of one-sided tests; Bold values represent significant results; °Significant differences found between schools according to the Snijders–Baerveldt method (2003). – = not measured.

De Vries, Candel, et al., 2006; Ennett & Bauman, 1994; Fisher & Bauman, 1988; Kandel et al., 1978).

One of the strengths of the present study was the inclusion of a number of alternative explaining mechanisms to counter a possible overestimation of selection based on similar smoking behavior. Adolescents highly preferred to reciprocate friendships and to become friends with friends of friends, which is in line with previous research (Burk et al., 2007; Snijders & Baerveldt, 2003). Gender similarity was another important criterion. These significant results as well as those of previous studies (McPherson et al., 2001), underline the necessity to control for such mechanisms when examining selection and influence processes.

The most remarkable finding of this study may be that support for influence of friends' smoking behavior on adolescent smoking was only found in Finland and the Netherlands. In all countries selection based on smoking behavior was more important than peer influence in explaining similarity in smoking status between friends. Although often suggested (Aloise-Young, Graham, & Hansen, 1994; Kandel et al., 1978; Sussman et al., 1990), our results do not entirely confirm the importance of peer influence. Our results differ slightly from a previous study on similar data (De Vries, Candel, et al., 2006), in which no support was found for peer influence in Finland and the Netherlands, but was found in Portugal. In this study (De Vries, Candel, et al., 2006) friendship composition changes were not taken into account and smoking behavior of friends as reported by the adolescents instead of actual smoking behavior of friends was used, which may have led to biased estimations of influence and selection processes. Furthermore, the present study uses data over a longer time period, which yields higher power for discovering effects. In addition, the influence and selection processes may change over time. Further research is needed to examine this possibility.

As in previous studies (Avenevoli & Merikangas, 2003; McAlister, Krosnick, & Milburn, 1984; West, Sweeting, & Ecob, 1999), we found support for parental smoking influences on adolescent smoking in Finland, the Netherlands, and Portugal. Support for influence of sibling smoking was only found in the Netherlands. These results might imply that a substantial number of adolescents were not influenced by their direct social environment but chose to smoke for different reasons. We did not find evidence that being more often selected as a friend (being popular) or selecting more friends oneself affected adolescent smoking behavior in any of the six countries. This is in contradiction with Valente and colleagues who reported that popular students were more likely to become smokers compared to less popular peers (Valente, Unger, & Anderson Johnson, 2005). This difference might be due to the different population or to the stronger control exerted in our study for alternative mechanisms.

This study was subject to limitations. First, self-reported smoking behavior was not validated by biochemical measures. However, under optimized measurement conditions that assure anonymity, self-reports have been shown to be reliable and to correspond well with biological indicators (Campbell et al., 2008; Dolcini, Adler, & Ginsberg, 1996). During the ESFA project, measurement conditions were optimized by guaranteeing strict confidentiality (De Vries et al., 2003). Second, no direct measures of parental and sibling smoking were available, which might have biased estimated parental and sibling smoking behavior effects. However, previous research has demonstrated that adolescents aged 13–17 years can be used as reliable sources to report on the smoking status of their parents (Harakeh, Engels, De Vries, & Scholte, 2006). Third, the use of a fixed name generator might have limited adolescents' possibilities to nominate their best friends. However, previous research, allowing 7th graders to nominate any number of friends, showed that on average only 4.09 friends were

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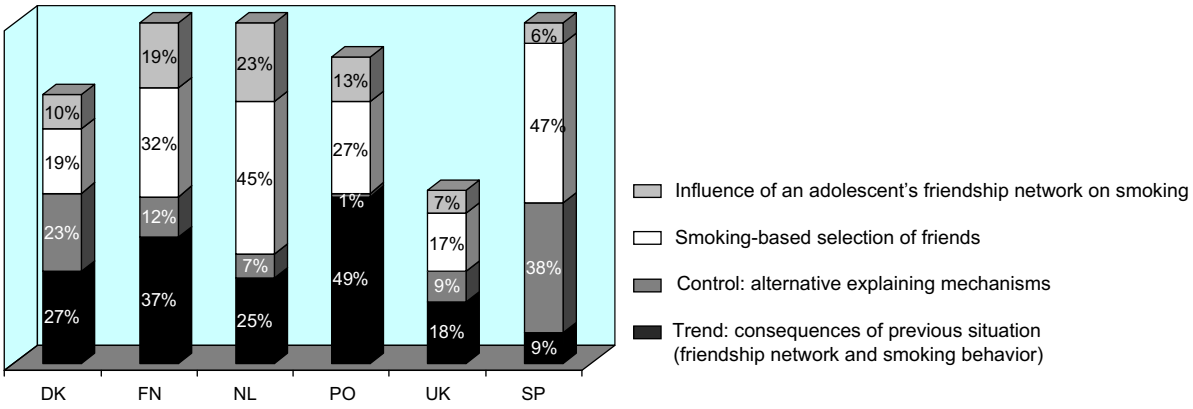

Fig. 2. The relative contribution of selection and influence processes to smoking behavior similarities between friends.

nominated (Cairns, Leung, Buchanan, & Cairns, 2003). Allowing more than five nominations might provoke adolescents to nominate peers who are not 'best' friends. Fourth, we focused on friendships within the same school grade. Although these specific friends form an important social environment, they do not represent the entire social network of adolescents. Older friends may be an important source of influence, and as adolescents grow older themselves, friends are more likely to come from various settings. Future social network studies should aim to include all friends outside and inside school. Fifth, we could not include classroom membership effects because this information was not available, which is a disadvantage mainly for the countries where schools were larger and school grades contained a higher number of adolescents (Netherlands, Portugal, UK), as SIENA makes the assumption that all network members are equally available as potential friends. This may have biased the transitivity parameter and it might have led to an overestimation of smoking-based selection since adolescents in the same classroom may have a higher chance to become friends. Future research should include measurements of classroom membership and test this possibility. Finally, differences between countries and between schools within countries were not explored. Although we tested for differences across schools, we did not examine school level factors such as educational level and school size. It will be interesting to include such factors in future multilevel analyses.

This study has several practical implications. First, if adolescents are less strongly influenced by their friends to start smoking than assumed earlier, it is conceivable they choose to smoke due to earlier formed smoking-related attitudes. In these cases, smoking prevention programs will probably benefit more from reinforcing non-smoking attitudes than from teaching adolescents to cope with social influences. Second, smoking prevention should not solely focus on social influence, but also consider selection processes. Previous research has already emphasized that peer network structure needs more attention within prevention programs besides the promotion of social influence skills (Audrey, Holliday, & Campbell, 2006; Campbell et al., 2008; Dishion & Owen, 2002; Pearson & West, 2003; Valente, Hoffman, Ritt-Olson, Lichtman, & Johnson, 2003). Especially in countries where influence processes play a role, prevention could benefit from creating non-smoking majorities within groups, working with popular peers as role models, or increasing self-awareness regarding imitation and selection. Finally, the different results across countries regarding influence processes call for a multilevel approach which could reveal the effects of cultural norms (Nichter, 2003), school size or classroom organization. Cultural norms may protect against smoking, but may also foster smoking as a normative behavior. Greater stability in classroom composition over years could promote friendship stability and decrease opportunities for selection as well as influence processes.

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