Selection or influence? The position-based method to analyzing behavioral similarity in adolescent social networks

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ABSTRACT
Assessing friends’ selection and influence effects on their behavioural similarity is a challenge in adolescent behaviour research. In the present article, I propose an evaluation method along with social network analysis to examine changes in friendship networks and behavioural pattern in order to identify the prioritization of selection and influence effects at the earlier stage of adolescent formation of behaviour. To test this proposed method, the empirical data is from Taiwan Youth Project. Results show that adolescents’ behavioural similarity with regard to academic performance and delinquent behaviour is particularly affected by the selection effect at first, and then influence effect jointly shaped the behaviour patterns. This proposed model testing network-behaviour covariance would provide an alternative way of thinking for educational practitioners when dealing with deviating adolescent behaviour as well as developing their pro-social behaviours.

Introduction and literature review

Introduction

Many social scientists have studied the causal relationship between individual behaviour and one’s social network. These studies focus mainly on understanding the interaction between individual action and social structure as well as their interdependence. In fact, friends as a role model playing a role in the formation of one’s values and behaviours (Corsaro & Eder, 1990). Through daily interaction between friends, their behaviours could be expected similar, which is common in salient individual attitudinal and behavioural dimensions and is the best example of the causal relationship between individual behaviour and one’s social network (Bishop, 2008; Baldassarri & Bearman, 2007; Coleman, 1961; Fararo & Sunshine, 1964).

Social scientists have long debated about the fundamental explanations for behavioural similarity between friends. The most notable issue about social influence or friendship selection effect on friends’ behavioural similarity has also been debated largely in the literature (Hirschi, [1969] 2002; Lazarsfeld & Merton, 1954; Sutherland, 1947). From social selection perspective, social scientists contend that people are more likely to have close connections with others who are like themselves (Lazarsfeld & Merton; McPherson et al., 2001). Studies have shown that this phenomenon appears in similar demographic groups, such as age, gender, race/ethnicity, or education, cultures and subcultures, or in groups with similar psychological characteristics, such as values and attitudes. By associating with others like themselves, people then share similar information, adopt similar attitudes, and engage in similar behaviours (McPherson et al.).
On the other hand, scholars who ascribe to the social influence perspective argue that the groups to which individuals belong (family, school, or organization) significantly shape and reshape individuals’ values, attitudes, and behaviours through the process of interpersonal influence (Friedkin & Johnsen, 1990). Consistent interaction helps to establish a uniformity of values and behaviours among their members (Festinger, 1954). Therefore, individuals who are influenced by their peers will assimilate their attitudes, values, and behaviours, which brings about the phenomenon of similarity within the group (Festinger; Sherif, 1936).

The dispute over the explanation of the selection-or-influence effect can be understood as whether a subgroup formed in a given network is due to its members’ common attributes or the ties based on a close relationship. To compare the strength of the two effects, studies applied quantitative methods to examine whether selection or influence causes similarity among group members (Degirmencioğlu et al., 1998; Kandel, 1978; Padgett & Ansell, 1993; Snijders et al., 2007; Steglich et al., 2010). Among them, in order to obtain a deeper understanding of this dispute, Snijders and his colleagues (2010) developed a seminal method known as stochastic actor-based model to separate the effects of selection mechanisms from those of influence ones. By doing so, the causal relationship between actors’ individual behaviour and friendship network structure is ascertained and the variance of which the two effects, in statistical terms, can be explained by actor’s attributes (selection effect) and/or characteristics of friendship network structure (influence effect).

Inspired by their elaborate methods, I alternatively explore the question of selection-or-influence effect on behavioural similarity by a proposed position-based model. This model is proposed to compare both an individual’s behaviours and network position in a given friendship network at two points of time, respectively, to examine which effect is more prevalent than the other among adolescents. The main purpose of proposing a position-based model here is to assess the weight of selection and influence effects on behavioural similarity before looking into the causal relationship between the response variable and any theoretical and empirical explanatory variables in either ‘selection’ or ‘influence’ model. To this end, in an elaborate example, I concern the joint dynamics of friendship and behavioural dimensions in adolescent peer networks. I apply the proposed method to compare one’s observable behavioural patterns with peer groups and examine similarity on a variety of behaviours, including academic performance, delinquency, and hours spent studying after school.

**Literature review**

When people share certain types of social relation, such as friendship, they behave and think similarly. This phenomenon especially has been noticed by social science on adolescence. Studies have shown that similarities among adolescents can be found in many aspects of their behaviours and attitudes. However, it is disputed whether a pair of friends’ behavioural similarity is due to certain shared endogenous attributes or the process of interpersonal influence. It could be a mutual causal relationship between selection and influence effects, and although these two explanations mixed, social scientists put their effort on differentiating these two points of view based on rigid theoretical perspectives.

(a) Selection perspective

In sociological literature, scholars explain the mechanisms of social connection forming a given social group among any given pairs of people are based on their personal attributes in common, such as gender, education, occupation, and/or socioeconomic status. That is, social groups are formed because of their members from similar social stratification in which they share similar values, culture, or even ideology. Sociologists are interested in the extent to which these common attributes group people into solid social structure, constraining or facilitating group members’ opportunities of
getting social resources in daily life. Such explanation of distributing social resources and their impact on individual’s social achievement and status is directly adopted and acknowledged in education system (Coleman, 1988).

Selection perspective in sociological field is more concreted to explain sociability in society (Simmel, 1949). For example, McPherson et al. (2001), in their classic study of network ties, found that since people tend to contact those who are like themselves, their behavioural similarities are reinforced through their interaction. Their study of the informal network ties (friendship) of students in small urban neighbourhoods revealed systematic evidence of substantial homophily in terms of demographic and psychological characteristics.

Other studies of homophily have provided empirical support for the selection approach in various fields. For example, Kupersmidt et al. (1995) examined friendship among young adolescents and found that strong similarity in gender, race, and academic achievement increased the odds of befriending. Studies on adolescent delinquent behaviours found strong evidence for the selection of friends with similar behaviours by analysis of sociometric data from longitudinal research about habits including substance abuse, smoking and drinking (De Klepper et al., 2010; Mercken et al., 2012). Robust findings in the literature indicate that engaging in similar behaviours could facilitate further interaction which would strengthen their friendship network.

(b) Influence perspective

The social influence theory explains similarity by emphasizing the interpersonal effect between friends. A person’s attitude or opinion about a certain issue is generally interpreted as an example of self-determination and expression of his or her personal desires; however, the empirical findings of social research suggests otherwise. Studies in the past decades have shown that groups to which individuals belong shape and reshape their attitudes (Festinger, 1954; Friedkin, 2001; Latané & L’Herrou, 1996; Sherif, 1936). For example, Sherif argued that when a group of people find themselves in an uncertain situation, they tend to seek consensus about how to respond from others in their group. Festinger (1950) developed the social comparison theory by further integrating these traditional social psychological perspectives with regard to group influence on individuals. His basic theoretical argument for the group’s influence is that individuals belonging to a given group tend to have a need to confirm if their attitudes differ from their peer members in the same group. This theoretical perspective has been widely utilized to analyse the complex group mechanisms of sharing information to their members.

In order to explore the mechanisms through which shared attitudes are distributed in a group setting through the lens of social comparison perspective, network analysts have developed several approaches for explaining the dynamics of reducing interpersonal disagreement and increasing consensus (Davis, 1973; Friedkin & Johnsen, 1990; Stasser et al., 1989). For example, the social influence network theory is applied to examine the relationship between attitude change and network influence in social group. Friedkin (1998) introduced this theory to define appropriate or socially acceptable attitudes that emerge from interpersonal contact effect. That is, social influence network theory argues that shared behaviours are seen as the function of their interaction within a peer group. Friedkin (2001, p. 169) adopted this theory to show precisely ‘how interactions among group members operate to transform an individual’s uncertainty and conflict into interpersonal agreement’.

The traditional selection perspective and social influence theory have been widely applied to explain the extent to which any given members’ attitudes and opinions on an issue change by looking into influential group members in the process of reducing interpersonal disagreement and increasing consensus. The original social influence network theory emphasized the set of influences over which most of the group are susceptible while selective perspective argues that adolescents who exhibit similar behaviours facilitate further interaction and strength the friendship network. The dispute over friends’ behavioural similarity is due to social influence or friendship selection has also
been debated abundantly in the literature. One popular method to answer this question, developed by Snijders and his colleagues, is called the stochastic actor-based models for network dynamics (De Klepper et al., 2010). Many subsequent studies address the issue of selection or influence on similarity rely on Snijders’ actor-based model in order to distinguish the exogenous effects (i.e. individual attributes) from the endogenous effects (i.e. features of social network structure; De Klepper et al., 2010). Below I review the theoretical arguments of their method of dynamic networks and behaviour. Then, I briefly explain the intention to propose a method to firstly determine which effect (selection or influence) is more prevalent on human behavioural similarity with statistical significance testing.

In their study, Snijders and his colleagues analysed selection and influence mechanisms on behavioural dimensions and showed the extent to which these mechanisms contribute to the examined level of network autocorrelation (the dynamic change of network structure). It formalizes the simultaneous, joint evolution of social networks and the behavioural/attitudinal characteristics of the network actors (Doreian et al., 1984). These models can be fitted to data collected in a panel design, where complete networks as well as changeable behaviours are measured.

There are three assumptions in their model. The first one is that in the underlying dynamic process, changes in network ties and behaviour occur continuously at stochastically determined moments. Based on this assumption, the model is a continuous time Markov process, where the totality of possible combinations of network ties and actor behaviours is represented as the state space (an abstract space representing possible states of a system). A point in the state space is a vector of the values of all relevant parameters of the system. Since the concept of state space is often used within a dynamic system, the state of a point in time \( t + d_t \) can be predicted from its state at time \( t \) through a differential equation.

The second assumption is that to distinguish the network changes of an actor from his/her behavioural changes, one must rule out the possibility that changes in network ties and in behaviour, or changes by two different actors occur at precisely the same point in time. The compound change that is examined between two points thus is interpreted as resulting from many small, unexamined changes that occur between the moments under observation (the current state is also the initial state for further developments, and where the probabilities for specific changes can depend on the entire current network-behaviour configuration). I also use this assumption when developing our method of determining selection-or-influence effect on behavioural similarity (see Section 3). For example, when one changed both his or her network and behaviour from time 1 to time 2, the process of this change followed at least two steps, network/behaviour changed and then behaviour/network changed. This assumption is crucial in terms of determining selection-or-influence effect on behavioural similarity.

The last assumption is that the first observation in panel dataset, which will later be analysed, is not modelled but conditioned upon, i.e. the starting values of the network ties and the initial behaviour are taken for granted. It implies that the evolution process is modelled without concern for the contingencies leading to the initial state, and that there is no assumption of a dynamic equilibrium.

(c) Conceptual framework

I recognize their justification for the first assumption that the underlying dynamic process, changes in network ties and behaviour occur continuously, following the Markov process in the model. Their actor-based model only takes one’s position in a given network structure into consideration and treats behaviour as individualized to evaluate selection or influence effect on individuals. However, I argue that behavioural similarity does not just happen between dyadic friendships, but among a group of friends. To think globally on both network structure and group behaviour leads us to utilize the position-based model instead of the actor-based approach to determine the network structure and group behaviour in order to examine the
dynamic changes of similarity among adolescents. By doing so, we are able to assemble many network features into one index, given an evolving behavioural pattern, to make a clear statement about whether adolescents’ behavioural similarity is more significantly determined by selection or influence.

In addition, Snijders’ stochastic actor-based model for network and behaviour coevolution follows the concepts of network autocorrelation, which underlie the interdependence of data in the use of linear regression models (Doreian et al., 1984). Hence, the fundamental hypothesis of ‘behavioral similarity among people who are closely related to each other’ could be tested by parameters of selection and influence and other control variables. These estimates of regression parameters are used to assess the explanation power over the variance of network autocorrelation so that the two main effects of selection and influence can be identified (Steglich et al., 2010, pp. 377–382).

(d) Goals of the study

Instead of using the approach of the continuous-time Markov chain of regression modelling, I apply the concepts of time series to describe the change of a sequence of network and behaviour measured at various time points. For example, observing a case of one’s performing the same behaviour but changing the network at two time points, I call it the selection effect by which people seek for behavioural homogeneity in a group; on the other hand, in a case of people’s changing their behaviour in response to the network they stably attached to at two time points, I view it as the influence effect.

The research hypotheses are specified as

(1) Social Influence Hypothesis

Based on the social influence hypothesis, I argued that adolescents’ friendship network distance that had evolved from the beginning of secondary school remained stable and influenced their behaviours later. Hence, I broadly examined the association between adolescents’ network distance and their behaviour, including academic performance (GPA and average number of hours spent studying after school) and delinquency (smoking and drinking alcohol). Through observing these behaviours, we were able to learn the extent to which adolescents’ friendship network distance in the prior wave facilitates behavioural similarity later.

(2) Friendship Selection Hypothesis

In the friendship selection hypothesis, I argue that adolescents’ behavioural patterns would significantly affect the structure of their friendship network. Again, I broadly examine the association between adolescents’ network distance and their behaviour, including academic performance (GPA and average number of hours spent studying after school) and delinquency (smoking and drinking alcohol beverage).

Therefore, in this study, the causal relationship between network and behaviour is not understood under a presumption of x (explanatory variable) and y (response variable) correlation, but under the observation of their coevolution at two time points. In other words, I do not take either behaviour variable or network variable as the dependent variable in a regression model and assess whether or not parameters of selection and influence are significant. I emphasize that determining selection and influence effects on behavioural similarity should be made under the investigation towards the coevolution of network and behaviour at two time points. The detail methodology developed in this study is discussed in the next section.
Research methodology/ method

A network position-based method

To explore the relationship between individual behaviour and friendship network structure, I compare the patterns of actors’ behaviour change while examining the relative network distance of any pairs of respondents in a network and its dynamic change over time. Multidimensional scaling (MDS) is a statistical tool for constructing a configuration to represent \( n \) points in \( t \)-dimensional space and how well interpoint distances in this configuration could represent the relational distance in network data (Freeman, 2005; Scott, 1988). Specifically, for any given configuration MDS processes a monotone regression of distance to match the differences of \( n \) vertices by looking for the minimum residual variance (called the stress) until the best-fitting configuration of points is detected (Kruskal, 1964a, 1964b). As a result, the differences of friend circles between any two egos \( i \) and \( j \) could be presented approximately by MDS. Here the measurement of network distance focuses on the features of network structure rather than behavioural patterns. This manipulated measurement assumes relative differences between any two egos can be detected even as time changes. After measuring the network distances among students within class boundary, we are able to analyse the change in their network distance and the relationship between the network distance and students’ behavioural patterns at different time period.

(a) Model specification

This study processes a dynamic analysis of the co-evolution of network and behavioural similarity. I consider testing the hypothesis that either selection effect or influence effect is more weighted than the other on behavioural similarity. I essentially agree upon the assumptions of Snijders’ stochastic actor-based model as described in previous section. That is, the concepts of Markov chain are applied in the model, and two states (network and behaviour) cannot change simultaneously. The method is elaborated below.

To test the hypothesis of selection and influence effects, I examine whether the differences among student behaviours are significantly associated with the network distances between the students through time. That is, in a given class, differences in students’ behaviour were compared to the network distances between them. Specifically, there are four key variables to denote adolescent’s behaviour and network distance from any other peers in a class:

- \( B_{ij}^{(t)} \) denotes in a given network (i.e. class) \( i \) ego \( j \)'s individual behaviour at time \( t \);
- \( B_{ij}^{(t+1)} \) denotes in a given network \( i \) ego \( j \)'s individual behaviour at time \( t + 1 \);
- \( N_{ij}^{(t)} \) denotes in a given network \( i \) ego \( j \)'s average network distance from alters within a homogeneous group at time \( t \);
- \( N_{ij}^{(t+1)} \) denotes in a given network \( i \) ego \( j \)'s average network distance from alters within a homogeneous group at time \( t + 1 \);

\( B_{ij}^{(t)}, B_{ij}^{(t+1)}, N_{ij}^{(t)}, N_{ij}^{(t+1)} \) are of value of 0 or 1. When \( B_{ij}^{(t)} = 1 \), it means ego \( j \) reported she or he had a certain behaviour at time \( t \) while \( B_{ij}^{(t)} = 0 \) means otherwise. Similarly, when \( N_{ij}^{(t)} = 1 \) it means the subgroup in a given network \( i \) to which ego \( j \) belongs showed a certain behaviour at time \( t \) while that \( N_{ij}^{(t)} = 0 \) means otherwise. By considering behaviour (\( B_{ij}^{(t)} \) and \( B_{ij}^{(t+1)} \)) and network (\( N_{ij}^{(t)} \) and \( N_{ij}^{(t+1)} \)) simultaneously, I follow the assumption of discrete-time Markov chain (Norris, 1997) to
identify an ego’s status at time $t$ and time $t + 1$, observing the convergent changes in behaviours. For convergent changes in behaviours, two main mechanisms of friendship selection and social influence triggering behavioural similarity are discussed.

Selection effect assumes an ego’s behaviour goes unchanged from time $t$ to time $t + 1$, but network distance had been changed; therefore, it is expressed as $B_{ij}^{(t)} = B_{ij}^{(t+1)}$ and $N_{ij}^{(t)} \neq N_{ij}^{(t+1)}$. On the contrary, influence effect assumes an ego’s friendship network goes unchanged from time $t$ to time $t + 1$, but behaviour had been similar with the peer group; hence, it is expressed as $N_{ij}^{(t)} = N_{ij}^{(t+1)}$ and $B_{ij}^{(t)} \neq B_{ij}^{(t+1)}$. The operationalization of determining similarity of behaviour ($B_{ij}^{(t)}$) and network ($N_{ij}^{(t)}$) is as follows. I first specify symbols using in the models where $i$ denotes a certain social setting (i.e. class in this study) and $i = 1, 2, \cdots, n$ while $j$ denotes the number of egos in the setting $i$ and $j = 1, 2, \cdots, i_m$, and $X_{ij}$ denotes an ego in a setting $i$. As to the co-evolution of network and behaviour, $B_{ij}^{(t)}$ specifies the behavioural type, say $B$. Then, at time $t$,

$$B_{ij}^{(t)} = \begin{cases} 1 & \text{if} X_{ij} \in B \\ 0 & \text{otherwise} \end{cases}$$

Next, I define the network state as

$$N_{ij}^{(t)} = \begin{cases} 1 & \text{if} R_{ij}^{(B)} \leq 1 \\ 0 & \text{otherwise} \end{cases},$$

where $R_{ij}^{(B)} = \frac{\text{Average network distance of ego } j \text{ with other alters of class } i \text{ satisfying } B}{\text{Average network distance of ego } j \text{ with other alters of class } i \text{ not satisfying } B}$.

Therefore, the classification in Table 1 for network-behaviour co-evolution was based on the assumption of discrete-time Markov chain that

$$Pr\left(S_{ij}^{(t+1)} = y | S_{ij}^{(t)} = x_0, S_{ij}^{(t-1)} = x_1, \cdots, S_{ij}^{(t-k)} = x_k\right) = Pr\left(S_{ij}^{(t+1)} = y | S_{ij}^{(t)} = x_0\right)$$

where $S_{ij}^{(t)} = \left(B_{ij}^{(t)}, N_{ij}^{(t)}\right)$. In a stochastic process with the Markov property, the future state ($S_{ij}^{(t+1)}$) depends only on the current state ($S_{ij}^{(t)}$), and does not relate to the sequence of states that preceded it. Therefore, classification of behaviour and network changes is determined only by the nature of the most recent change.

(b) Model determination

Secondly, determination of selection or influence effect is based on the criteria below.

**Table 1.** Means and SDs for sample in TYP project.

| Variable          | Level of Measurement | Mean (%) | $s.d.$ | Min. | Max. |
|-------------------|----------------------|----------|--------|------|------|
| Location          | Dummy                | 38.62    |        |      |      |
|                   | 1: Taipei City       | 39.33    |        |      |      |
|                   | 2: New Taipei City   | 22.04    |        |      |      |
|                   | 3: I-Lan County      |          |        |      |      |
| Gender            | Dummy                | 51.23    |        |      |      |
|                   | 0: male              | 48.77    |        |      |      |
|                   | 1: female            |          |        |      |      |
| Age at wave 1     | Ratio                | 13.301   | .474   | 13   | 17   |
| Class size        | Ratio                | 33.210   | 4.941  | 14   | 44   |
| Friendship Density| Wave 1               | 085$^a$  | .025   | .046 | .220 |
|                   | Wave 2               | .092     | .027   | .033 | .275 |

Note. a. The average density of 81 class samples at wave 1 is based on a at most 3 friends nomination for each respondent.
Let $p_i$, $q_i$ denote the examined ratio of class $i$'s change of state from time $t$ to time $t + 1$ caused by influence and selection, respectively. Note that $p_i + q_i$ is unnecessarily equal to 1 and then I define

$$
\mu_i = \frac{p_i}{p_i + q_i} - \frac{1}{2}
$$

$\mu_i$ indicates which transformation of influence and selection has a greater impact on class $i$. When $\mu_i > 0$ (or $\mu_i < 0$), the influence (or selection) effect on class $i$ is more than the selection (or influence). I regard $\mu_i$'s, $i = 1, 2, \ldots, n$, as an independent and identically distributed $(i.i.d.)$ sample from a distribution $Z(\mu, \sigma^2)$ with mean $\mu$ and variance $\sigma^2$.

As define earlier, influence effect for ego $j$ in setting $i$ is prevalent if the state vector $(B_j^{(t)}, N_j^{(t)})$ from time $t$ to time $t + 1$ satisfies $(B_j^{(t)} \neq B_j^{(t+1)} \text{ and } N_j^{(t)} = N_j^{(t+1)})$. Hence, equation above can be expressed as

$$
\mu_i = \frac{\sum_{j=1}^{n_i} I\{g_j^{(t)} \neq g_j^{(t+1)} \text{ and } N_j^{(t)} = N_j^{(t+1)}\}}{n_i} - \frac{1}{2}
$$

where $I\{A\}$ denotes the indicator function of set $A$. And, $n_i^* = n_i - u_i$, where $n_i$ is the number of egos in class $i$, and $u_i$ is the number of egos in class $i$ whose state went unchanged from time $t$ to time $t + 1$.

Our hypothesis of the selection and influence effects on behavioural similarity states that influence and selection have equal impact on the population of groups. Then, letting $\lambda = Pr(Z(\mu, \sigma^2) > 0)$, and

$$
H_0 : \lambda = \frac{1}{2}
$$

$$
H_1 : \lambda \neq \frac{1}{2}
$$

The critical value of the test of zero median is determined by the standard binomial test based on

$$
\sqrt{n\hat{\lambda}} \to N(0, \delta^2)
$$

where $\hat{\lambda}$ is the sample median of $\{\mu_i, 1 \leq i \leq n\}$ and $\delta^2 = .25$ under $H_0$.

(i) Empirical application: Friendship network distance in behavioural similarity

(a) Setting

To examine my proposed Understanding the causal relationship between friendship networks and adolescent behaviour requires detailed population-level data on the structure of friendship patterns within many different classes in various schools. This study utilized data from Taiwan Youth Project (TYP) with 2 waves of data collection, an available secondary data open to the public dataset collecting adolescent representatives national wide since they were in 7th grade nested within school samples in Taiwan for three waves between 2000 and 2002. The panel data of TYP, which emphasizes social and cultural contexts of adolescents’ educational experiences and change, allowed for an examination of their psychological well-being throughout secondary school. For TYP instrument more details, please refer to the Center for Survey Research, Academia Sinica, Taiwan (https://survey.sinica.edu.tw/Eweb/) and Yi (2011).

As part of the TYP, selected secondary school 7th grade students were asked about various experiences, including relationship with their family and peer students, attitudes towards social values, norms, and their friendships in class for three times from their junior to senior years. During the course of the project these same participants were interviewed three times in subsequent years until they reached high school. Researchers were able to examine changes in the subjects'
interactions with their families and peer groups, attitudes, and opinions during social situation and in the classroom, and most importantly, their friendship networks in class during adolescence, a significant stage in the forming of the personality.

The TYP data (Yi, 2011) was collected at 81 school samples in three areas, Taipei City, New Taipei City, and I-Lan County. Friendship networks, delinquency behaviours, and other daily issues were measured at three time periods from 2000 to 2012 (three years in a roll). The panel included data for 2,690, 2,683, and 2,664 from three waves, respectively. The measure of social networks was constructed by asking students to name their best three friends in the class. They were also asked about daily activities, such as music genres, smoking, alcohol and drug use experiences. In this study, I examine the data from the first two waves of the TYP subjects: Wave 1 was collected when student samples were in first semester of 7th grade, and data in wave 2 was collected in the following fall semester. These data provided insight into the effect of peer relationships on adolescent life experiences.

The questionnaire in the first wave was designed with five types of information, including the background information of students and their parents, relationships with their family and peers, activities in school, health issues, and friendship networks. In the following waves, the questionnaires were slightly revised; however, questions about friendship networks and various adolescent behaviour and attitudes were preserved to assess any changes.

In the TYP survey the first wave of data was collected when students enrolled as 7th graders and just started adjusting to a new learning environment and making new social relationships so that exogenous factors of social influence and social selection among them can be minimized. In addition, for comparing the two ended points of a time interval, the following dataset is as the other observable reference point of students’ behaviour and network so that dynamic change between the first and second waves was recorded. Therefore, the first two waves of data were used in this study to examine the co-evolution of network-behaviour. The selected questions from these two waves of this study are included below. In order to highlight behavioural similarity between friends, I selected three questions pertaining to behaviours, including academic performance and delinquency: (1) Average hours spent studying after school (academic performance); (2) GPA rank in class (academic performance); (3) Questions about smoking or alcohol consumption since starting 7th grade. Table 1 highlights our strategy for examining the causal relationship between friendship formation and behavioural similarity. Each cell indicates that each respondent belongs to a group in which her or his behaviour was similar with other members (behavioural similarity) or to a group in which her or his behaviour was dissimilar to others (behavioural dissimilarity).

Here I define selection effect as involvement in a close friendship network distance to one group with behavioural dissimilarity at time t, but then belonging to another group with behavioural similarity at time t + 1 (respondent did not change her or his behaviour, but the network distance did change). In contrast, the influence effect is defined as belonging to the same group at time t and time t + 1, but later one’s behaviour assimilated to the group at time t + 1 while originally the respondent’s behaviour was different from that of the group members’ at time t (the respondent did not change her or his network distance, instead the behaviour changed).

In this study I focus on students’ convergent changes in behaviours by either selection effect or influence effect. Selection effect means that the respondent maintained her or his behavioural pattern from time t to time t + 1, but selected the new group with behavioural similarity at time t + 1 instead of the previous group at time t. This is called selection effect on homophily. On the other hand, influence effect means that the respondent stayed in a group with behavioural dissimilarity at time t, but later she or he changed her or his behavioural pattern in response to the group. Therefore, homophilic influence means one stays in a group and her or his behaviour eventually becomes similar to the group as a result of interpersonal influence.
Table 2. Percentage of types of dynamic change of friendship structure and behavioural pattern.

| Type of Change      | GPA rank | Study Hour | Delinquency |
|---------------------|----------|------------|-------------|
| No Change           | avg. 47.049 | avg. 36.239 | avg. 39.309 |
| Heterophilic Change | avg. 20.951 | avg. 31.626 | avg. 26.492 |
| Homophilic Change   | avg. 32.796 | avg. 32.134 | avg. 34.199 |
| N^a                 | 66       | 62         | 49          |

Note. a. The number of sample size would be various because I excluded those sample classes with less than 30 students (the valid sample size is 66) and those with missing value in terms of behaviour questions (no missing value in variable of ‘GPA rank’, 4 out of 66 sample classes had missing value in variable of ‘Study Hour’, and 17 out of 66 sample classes had missing value in variable of ‘Delinquency’).

The next step was to determine the friendship network distance among adolescents, which was used to determine to which behavioural similarity group a respondent belonged. The TYP study contains the detailed social network data for students. Here, students were asked to name their best friends in their class. Friend nominations were recorded by students’ IDs within each class, and in this way we were able to create the complete social network in a class, thereby collecting 81 friendship networks from class samples in each wave. One or two class samples were selected from each school and the number of participants in class varies from 14 to 44 depended on the class size. The network composition remained the same across each measurement period (i.e. the data included nominations among adolescents from the first measurement occasion). A total of nearly 2,700 students completed the self-administered questionnaires with valuable friendship information for further analysis. Table 2 defines the variables used in the analysis and the sample means and standard deviations when applicable. After the measurements used in the analyses were described, the specific models were also discussed.

As to various network profiles for all 81 classes, the data shows that the average friendship density of the 81 classes was stable and relatively low, showing that friend nomination tended to be mutual, which resulted in sub-grouping within classes, and that few ties existed between these sub-groups. It appeared that the contours of the friendship structure are stabilized; therefore, the main question was whether general behaviours could thus be formed and maintained. In other words, I learn from the friendship network graph that adolescents gradually develop an awareness of in-group favouritism and develop affinity for one’s in-group over the out-group. I examine whether behavioural homogeneity within the group existed within these sub-groups and further explored whether social influence or friendship selection causes such similarity.

Results

This study processes a dynamic analysis of the co-evolution of network and behavioural similarity which I call ‘position-based model’ to examine changes in friendship networks and behavioural pattern. Dynamic changes in friendship network structure and behavioural patterns consist of three categories, no change, heterophilic change, and homophilic change. I describe the meanings of first two categories briefly and then focus on the third one, which is our main target of co-evolution of network in the position-based model to unpuzzle the proposition of selection-or-influence effect on behavioural similarity. Table 2 presents the percentage of each category by behaviour-and-network pattern from the sample classes. I found that the category of ‘no change’ across all three behavioural measurements had the highest proportion. That is, about 47% of students responded that their GPAs were similar to their peer group and their GPA performances were similar at two measurement occasions. With regard to the time spent studying after school and delinquency, the percentages of ‘no change’ were approximately 36% and 40%, respectively, which indicated that adolescents’
friendship structure and behavioural patterns had been relatively stable since moving to a new school where I assumed the independence of social networks from previous behaviour. Since the discussion of mechanisms of keeping adolescent’s friendship networks and behaviour stable over time is beyond the scope of this study, I do not discuss the meaning and implication of this category further here.

Heterophilic change is another category of dynamic change of friendship networks and behavioural patterns in which adolescents’ behaviour would be dissimilar to the group to which they belong. This could result from the change of dissimilarity in both network and behaviour simultaneously from time \( t \) to time \( t + 1 \), in which behavioural patterns are maintained but the friendship network changes from a homogeneous group to a heterogeneous one, or in which the friendship network is changed but the behavioural patterns become dissimilar to the group to which they belong. Here I found that the phenomenon of heterophilic change did in fact occur among adolescents and that the percentages of this type in the data sample were approximately 21% in GPA rank, 32% in hours spent studying, and 26% in delinquency (Table 2), proving that a certain number of adolescents behaved differently than the majority of the group to which they belonged. Although we can separate the effect of friendship selection from that of social influence on heterophilic change of friendship network and behavioural pattern by using the method we developed in this study, the existing literature, to the best of my knowledge, has yet to provide theoretical perspectives to explain why friendship selection or social influence would encourage one to behave differently than the group to which they belong.

Homophilic change is the status we refer to behavioural similarity. We found the percentages of homophilic change across three behavioural measurements were close: 33% in GPA rank, 32% in hours spent studying, and 34% in delinquency (Table 2). This implies that the phenomenon of homophilic change occurred more often than that of heterophilic change. Here, we are interested in exploring the mechanism of adolescent behavioural similarity, and two main effects of selection and influence based on theoretical perspectives were examined to determine which one is more prevalent among adolescents with statistical significance.

Table 3 presents the percentages of friendship selection effect and social influence effect on homophilic change based on three behavioural measurements using the standard binomial test as described in Section 3.

In general, I found that the average percentages of influence effect were higher than selection in terms of GPA rank and hours spent studying, but the reversed finding was true for delinquency, meaning the selection effect was more significant than the influence effect for this particular behaviour. More specifically, I use the standard binomial test to examine the null hypothesis that influence and selection effects are equal (\( H_0 : \lambda = \frac{1}{2} \)) versus an alternative hypothesis that one is stronger than the other (\( H_1 : \lambda \neq \frac{1}{2} \)). For behaviour variable of GPA rank, the result showed that the estimate binomial probability of influence effect is .530 (35 out of 66 sample classes had \( \lambda \neq \frac{1}{2} \) with binomial \( z \)-ratio = .37 and \( p < .1 \), implying influence effect was slightly more significant than

| Table 3. Standard binomial test – influence and selection effects on behavioural homophilic change. |
|------------------------------------------|---------------------------------|---------------------------------|
| Effect                              | GPA rank          | Study Hour          | Delinquency          |
| Influence                           | probability 4.74   | probability .341    | probability .298     |
| Selection                           | .526              | .659               | .702               |
| Binomial \( z \)-ratio               | \(-3.7^{a}\)      | \(-1.79^{**}\)     | \(-3.43^{***}\)    |
| N                                  | 66               | 61^{a}            | 38^{b}             |

Note. \( p < .1; ^{*} p < .05; ^{**} p < .01; ^{***} p < .001 \)

a. In 1 out of 62 sample classes, no students showed the homophilic change of behaviour-and-network relationship.

b. In 11 out of 49 sample classes, no students showed the homophilic change of behaviour-and-network relationship.
selection effect on academic performance. That is, in a peer group, adolescents would be vulnerably infected by friends either to get good grades or to lower their grades; however, it cannot be ignored that to some degree selection effect would also play a role to group students with similar academic performance together.

As to behaviour variable of hours spent studying, the estimate binomial probability of influence effect is .623 (38 out of 61 sample classes had $\lambda \neq \frac{1}{2}$) with binomial z-ratio = 1.79 and $p < .01$, indicating that influence effect is more prevalent than selection effect among adolescents with regard to the length of time to study. In other words, individual students' length of time to study would be influenced significantly by their friendship network, in which friends with longer time to study help others to study longer while friends with shorter time to study hinder their peers to spend longer time to study.

![Figure 1](image)

*Figure 1.* Distribution of percentages of influence and selection effects on behavioural similarity.
Last, for behaviour variable of delinquency, the estimate binomial probability of influence effect is \(0.211\) (8 out of 38 sample classes had \(\lambda \neq \frac{1}{2}\)) with binomial z-ratio = \(-3.41\) and \(p < .001\). Obviously, selection effect with probability of \(0.789\) is highly statistically significant to support the adage of ‘birds of a feather flock together’, the phenomenon of homophily. That is, adolescents with delinquent behaviours would tend to group together to make their friendship.

Therefore, by applying the proposed statistical method, we are able to examine which effect is more prevalent to foster friends’ behavioural similarity and in this empirical study, we rejected the null hypothesis that the influence effect and selection effect are of equal strength on adolescents’ academic performance and delinquent behaviours. Figure 1 shows the percentage distribution of influence and selection effects on three behavioural measurements to highlight which effect was able to foster a higher level of homophilic change among adolescents.

When we examine the distribution of percentage of influence and selection effects on the three behaviours listed in Figure 1, it was clear to show how many sample classes had a certain percentage range for either influence or selection effect on behavioural similarity. For example, at the top of Figure 1, there are 13 sample classes showing a 100% influence effect on GPA rank, and there were 35 out of 66 sample classes that showed more than 50% of influence effect on this behavioural similarity. This indicates that the influence effect was stronger than the selection effect in this case. Similar observations were found in the behavioural similarity of hours spent studying: 11 sample classes with 100% of influence effect, and 38 out of 61 sample classes showed more than 50% of influence effect on this behavioural similarity. On the contrary, there were 17 sample classes showing 100% of selection effect on the element of delinquency, and 30 out of 38 sample classes showed more than 50% of selection effect on this behaviour (the bottom of Figure 1). This indicates that the selection effect was relatively stronger than that of the influence on adolescent delinquency. The distributions of influence and selection effects on behavioural similarity corresponded to the findings in this study that social influence effect was statistically significant on adolescents’ academic performance while selection effect played a significant role on adolescent delinquency.

**Discussion**

I dealt with two issues in this study. First, we studied the complex issue of whether behavioural similarity between friends is determined by social influence or friendship selection. With regard to homophilic change of adolescents’ friendship network and behavioural patterns, behavioural similarities due to social influence or friendship selection have been widely investigated. This is a seminal method of evaluating the co-evolution of network and behaviour in one network, which has been applied to separate the effect of selection from influence (Snijders, 2001, 2005; Snijders et al., 2007; Steglic et al., 2010). This model of network-behaviour co-evolution was developed by Snijders and his colleagues to explain the dynamic change of network structure and behaviour. Their study presents an alternative account of the model of the co-evolution of network and behaviour in class boundary. However, I adopt this approach by developing a position-based model to examine changes in friendship networks and behavioural pattern. I use this method to determine which of two effects, selection and influence, is more prevalent than the other on behavioural similarity. To describe and model the selection and influence processes, I formulated the theoretical modelling framework based on individual behaviour embedded in the friendship network, which could cause that behaviour to change.

The basic data structure was in the form of a panel dataset depicting the relationships and behaviour, which means that for a specific time period, the friendship network and their behaviours in the same group were recorded. According to the selection process, we hypothesized that shared levels of behaviour of any two adolescents would encourage friendship formation and maintenance between them. On the other hand, the influence process argues the opposite causal effect in which friendship for adolescents’ behavioural similarity is salient. Hence, this study incorporated adolescents’ experiences of school in terms of academic performance and delinquency, and their friendship networks to clarify two opposite effects (selection and influence) on adolescents’ behavioural similarity.
I explore a dynamic social cognition mechanism in which individuals’ positions on issues were weighed and combined with others during the process of opinion revision. Influence effect on friends is an iterated interdependent process, whether between two friends or in a group. The common result of this iterated interdependent influence among friends is an increase in friends’ similarity over time. In this study, I define both influence and selection as sources of friends’ similarity.

The role of influence process – friendship networks in conditioning adolescent’s behaviours, attitudes, and opinions has been supported by robust findings in the literature. Social influence scholars argue that the group to which individuals belong (such as family, school, or organization) shapes and reshapes individuals’ values, attitudes, and behaviours. Such social groups are consistent in terms of values and behaviour among their members (Festinger, 1954). Therefore, individuals who are being influenced by their significant others, will assimilate their attitudes, values, and behaviours, which leads to the phenomenon of similarity among group members (Festinger, 1954; Friedkin & Johnsen, 1990; Sherif, 1936).

The selection process influences the configuration of the friendship network, while the concept of homophily explains the phenomenon that people tend to have close connections with others like themselves (Hirschi, [1969] 2002; Lazarsfeld & Merton, 1954; McPherson et al., 2001). Studies show that the phenomenon of homophily appears among individuals with similar demographic characteristics, such as age, gender, race/ethnicity, or education, who are from similar cultures and subcultures, or have similar psychological characteristics, such as aspirations, attitudes, and beliefs.

To examine these two opposing theoretical perspectives, I studied various dimensions of adolescents’ school experiences from 7th grade to 9th grade, and their friendship network (size and density) based on scanty demographic information. In the findings, homophilic change occurred in 33% of the sample classes, slightly higher than heterophilic change. In addition, I found the influence effect was greater than the selection effect in terms of academic performance (i.e. GPA rank and hours spent studying after school). This result showed that social influence could be a key to motivating adolescents’ studies. The effect of social influence in this case could be that adolescents learn socially acceptable behaviour from the significant others. Students with better academic performance would create a positive attitude towards learning to encourage others achieve academic success as they do so that good behaviour can be reinforced among group members. On other hand, the influence effect was also shown to be a negative outcome in which adolescents’ motivation to learn would decrease when they associate with a group with low academic achievement. Therefore, the influence network overwhelmingly conditions a social cognition mechanism of behaviour, which especially affects academic performance.

However, in regard to delinquency, we found the selection effect was stronger than the influence effect. For example, non-delinquent group members may not be influenced by their delinquent peer group, but would choose to associate with those who are law abiding. On the other hand, delinquent adolescents would group together gradually. This phenomenon is caused by the desire of adolescents to seek recognition from others with similar attributes to justify their delinquency; the strong effect of selection. Hence, the phenomenon of behavioural homophily appears among adolescents with similar behavioural patterns. Since the selection effect plays a significant role in adolescents’ delinquency, it implies that non-socially acceptable behaviours would not spread from one adolescent to another, but act as a mediator to pull those delinquent adolescents together.

Limitations

Network position-based method guides us to determine that an adolescent would become closer to a certain group (like the group in which everyone smokes) than the opposite group (non-smokers) if the average network distance is shorter than the other. We are able to identify an adolescent as belonging to a group with a certain type of behavioural similarity based on the shorter average network distance, compared to the opposite one (in which three behavioural measurements were dichotomous. Good academic performance paired with non-delinquency, while poor academic performance paired with
delinquency). This method of equilibrium network distance calculation can be conditioned on adolescents’ characteristics for the purpose of study although we did not control for other factors in this study; however, this can be a useful tool for creating a single index of aggregating network characteristics for studying friendship network structure and how it changes. Once the association between adolescents and their homophilic group was identical at two periods of time, we are able to examine the dynamic changes within their friendship network structure and behavioural patterns.

**Conclusion**

Traditional social bond theory (selection effect) and social influence theory (influence effect) have been widely applied to explain the extent to which any given members’ behaviours change by referring to significant others in the process of reduction of interpersonal disagreement and then the formation of consensus or *vice versa*. The original model of the social influence network theory emphasizes the set of influences on the group members on any given members who are particularly susceptible to the influence of others. On the other hand, friendship selection perspective argues that adolescents who exhibit similar behaviours could facilitate their further interaction and then construct a close friendship network. In this study, I manipulated features of network structure and individuals’ behaviours for the joint analysis of selection-or-influence effect on behavioural similarity within adolescent friendship networks. The findings show that both selection and influence effects each play a part in explaining adolescents’ behavioural similarity in terms of either academic performance or delinquency. That is, the influence effect is significantly stronger than the selection effect on academic performance, which means adolescents are more vulnerable to the influence by their peer reference group in terms of socially expected behaviour. On the other hand, the selection effect is a primary mechanism for determining if adolescents will exhibit delinquent behaviour, which implies that socially inappropriate behaviour would be reinforced among the delinquent group since its members would seek recognition or identity in such a behaviourally similarity group.

Second, and the key contribution in this study, is that I develop a model of network distance to measure adolescents’ position in the friendship structure, illustrating the extent to which the closeness of any pair of nodes would come to be at equilibrium stage through time evolution. Prior studies have focused on the presence of friendship to illustrate the relationship between network structure and individual behaviour. In fact, unobservable or undirected ties between nodes also constrain the structure of the network (like triad, structure hole, number of paths, and so on) and might contribute to the explanation of this relationship.

By proposing a position-based model for identifying selection and influence effect on adolescent behaviours, this provides insightful scientific knowledge about the mechanism of adolescent behaviour pattern and the process of change. The empirical findings significantly point to a brand-new direction for educational practitioners’ interpretation and use of assessment of adolescent behaviour formatting process with regard to gathering and discussing information from social network structure in order to develop a deep understanding of what adolescents behave with their friendship as a result of their daily experiences. Therefore, further more studies should be done on heterophilic change among adolescents to provide insightful theoretical framework in the line of this research.

**Notes**

1. Students could nominate up to 5 best friends from their classmates in the first wave of survey, but up to 3 best friends in the second and third waves; for consistent comparison of friendship network across three waves, we only picked up the top three friend nomination to build friendship network within classes.

**Disclosure statement**

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