

Adolescent delinquency and diversity in behavior settings

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Abstract

Purpose: This study aimed to test whether adolescents' delinquency is related to the geographic, functional and social *diversity* of the behavior settings that they are exposed to. *Methods:* Data were collected in a two-wave panel study amongst 616 adolescents. In the first wave, diversity was measured using a space-time budget interview recording their activities from hour to hour during four days. Self-control, morality, peer deviance, unsupervised peer activity, and parental supervision were measured using a self-report questionnaire. Delinquency was measured using self-report questions in the second wave. *Results:* The findings demonstrated that setting diversity is positively related to delinquency. For geographic and functional setting diversity, a substantial part of the positive association is independent of gender, age and the other explanatory variables. *Conclusions:* Adolescents' delinquency is not only affected by the overall contents of the settings that they encounter, but also by how much the content of settings varies over the course of the day.

Keywords

activity pattern, adolescent delinquency, behavior setting, diversity, routine activity, space-time budget

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Introduction

Environmental theories of crime, in particular crime pattern theory (Brantingham and Brantingham, 2008) and routine activity theory (Felson, 1994) emphasize that knowing the situations that people are exposed to – where they go, when and with whom – is crucial to understanding whether they become involved in crime. Although both theories have been around for over three decades and have strongly influenced criminological scholarship, their core concepts have seldom been measured explicitly. As a result, detailed empirical data on where people go, when, and with whom, are seldom collected in criminological research (notable recent exceptions are Bichler et al., 2011; Wikström et al., 2010, 2012).

This article reports on a two-wave panel study in which a space-time budget interview was used to record, hour by hour, the activities and whereabouts of 616 adolescents over the complete course of four days. The measurements included the geographic locations, the functions of the places, and the people present in the settings where they spent their time. The recorded data provide detailed information on the daily (routine) activities that are part of the adolescents' lifestyles, which is more precise than the self-report questionnaire items that have been used in prior criminological research (e.g. Osgood et al., 1996) asking adolescents how frequently they generally perform certain activities (e.g. hanging around with friends, going on dates, performing active sports or watching TV). Just within the limits of what was feasible, both time and space were measured at fine scales: time by hour, and space by position in a 200 by 200 meter grid that was overlaid over the study area. A major advantage of the detailed measurement of routine activities across time and space is that it allows us to gain insight into how diverse the situations are that the adolescents are exposed to, whereas the more common questionnaire formats only measure *how often* they are exposed to specific situations.

We use these data to establish whether adolescents' involvement in delinquency is related to the *diversity* of the settings that they are exposed to, and whether this relation is independent of the relation of delinquency with the nature of those settings (in particular time spent with peers in unstructured activities in the absence of adult supervision) and with other well-established individual correlates of delinquency. These hypotheses are straightforward and simple, yet have never before been explicitly formulated as part of either crime pattern theory or routine activity theory. The main argument for expecting these associations is that for an individual who finds him or herself in a given setting, the only way to become exposed to new criminal opportunities is to be confronted with a setting change, a change that can be geographic (by traveling to another location), functional (by moving into a location with a different function) or social (by someone else leaving or entering the individual's setting), or a combination of these three types of setting changes. If this is true, being exposed to a more diverse array of settings implies being confronted with more criminal opportunities.

Our diversity hypothesis focuses on the geographic, functional and social *structure* of activities in addition to the nature of the *content* of these activities. We expect that the more geographically, functionally and socially diverse the settings are that adolescents are exposed to, the greater their involvement in delinquency, that is, the likelihood of becoming involved in delinquency, and if involved in delinquency, the number of

offenses committed. To our knowledge, this hypothesis has not before been addressed in the literature on adolescent delinquency.

We recognize that setting diversity may be associated with many other variables, some of which are closely linked to delinquency. These other variables include the content of the adolescents' daily activities, in particular the amount of time spent unsupervised with peers in unstructured activities, but they also include characteristics of the adolescents themselves, such as self-control and morality, and aspects of the behaviors of people in their environment, such as parental supervision and peer deviance. Finally, other variables also include sex and grade.

In addition, we hypothesize that at least part of the association between delinquency and geographic, functional and social diversity is independent of these other variables. In this article, we will test both hypotheses and also explore any differences between the associations of geographic, functional and social diversity with adolescent delinquency.

Theoretical elaboration

Environmental theories of crime emphasize situational rather than personal determinants of crime. In other words, they attempt to explain why the same person commits crimes in some situations but not in others. Many etiological theories of criminal behavior do just the opposite, they attempt to explain why some persons but not others commit crimes in any situation. These theories, in particular those that focus on juvenile delinquency, generally model delinquent behavior as being shaped by characteristics and attitudes of the *individual*, their *parents and family situation*, their *bonds with school and teachers* and their *peers*.

In this section we combine the situational and etiological frameworks by developing a hypothesis about *differences between individuals*, but differentiate these individuals on the basis of the *situational influences that they are exposed to*. To accomplish this, we first need a conceptual framework to define *activity patterns* and *behavior settings*.

The *activity pattern* of individuals describes their actions and experiences in at least five dimensions. First, it describes their actions as they unfold over *time* (e.g. over the 24 hours of the day). Second, it describes their actions as they move across geographic *space* (e.g. as if they carry GPS tracking equipment). Third, it describes the *function* of the place where they perform the activity (e.g. whether it is a bar, a classroom, or a bedroom). Fourth, it describes the nature of the *activities* (e.g. playing soccer, doing the dishes, or sleeping). Fifth, it describes the *social configuration* of the situations that the individuals are exposed to (e.g. whether alone, with parents, with a teacher, or with peers).

A *behavior setting* is a useful concept for thinking about how the environment shapes individual behavior. It is defined as the part of the social and physical environment that individuals can perceive with their senses (Wikström, 2006). Behavior settings are small and variable. They are by definition *small* because they can be overseen and overheard with the senses. A neighborhood or a school are therefore not true settings, because they are too large. A street segment and a classroom are settings, as they are small enough to perceive activities taking place with one's senses. Settings are *variable* because a change in one single dimension generates a new setting. A classroom where an adolescent is

alone is different from the same classroom where he or she is with peers, which in its turn is different from the same classroom with a teacher present.

Behavior settings are the contexts in which opportunities may arise that are necessary for crimes to be committed. As people go about their daily activities, they constantly enter and leave settings. For example, they leave home, wait for the bus at the bus station, enter the bus, leave the bus, walk a block to school, enter the classroom, leave the classroom, and so on.

A basic assumption underlying our hypothesis is that criminal opportunity is typically constant within a given behavior setting. In other words: given the geographic location, the function of the place and the people present in the situation, we would not expect criminal opportunity to change without any change in at least one of these three aspects of the setting, that is, geographic location, or function, or people present. A setting change is thus a necessary (but not sufficient) requirement for crime because it potentially generates new opportunities for crime. In support of this argument, a recent study (Lemieux and Felson, 2012) demonstrated the activity-based risk of criminal victimization (the risk calculated per unit of time spent in an activity), is particularly high during 'in-transit' activities, which include travel between home and work, between home and school and between home and other activities. The authors suggest that the elevated victimization risk during travel is caused by the 'constant flux' of the opportunity structure, that is, the many changes of the social and physical settings that people are exposed to when traveling. As the opportunity structure for victimization is mirrored in the opportunity structure for offending, a similar regularity may hold for offending.

If a setting change is necessary to trigger crime, then a possible situational explanation of differences in delinquency between adolescents is that some adolescents are exposed to a more diverse array of behavior settings than others, and thereby are exposed to more criminal opportunities than their peers who are exposed to less diverse behavior settings. This argument does not suggest that all settings provide the same level of criminal opportunity, but it does imply that setting diversity creates an additional risk; if two adolescents spend their time in settings that are equally criminogenic on average, the individual whose exposure is more diverse is more likely to become involved in delinquent behavior. Diversity would matter even if all settings were equally criminogenic.

Note that the diversity of behavior settings may either entail a change in geography (if the individual moves to another location), a change in functional place (e.g. going from the classroom to the school yard) or a social change (e.g. a teacher enters the classroom), or two or all three together. Therefore the first hypothesis to be tested can be formulated as follows:

Hypothesis 1: The more geographic, functional and social *diversity* (*behavioral setting diversity*) adolescents are exposed to in their daily routines, the more they will be involved in delinquent behavior.

Prior research has shown that the likelihood of delinquent behavior by adolescents is affected by characteristics of the focal persons, of their (leisure) activities, of their parents and of their peers. Delinquency is more common among adolescents who lack self-control (e.g. Gottfredson and Hirschi, 1990; Hay, 2001; Lagrange and Silverman,

1999), who have low moral standards (Wikström, 2006), who are poorly supervised by their parents (Dishion and McMahon, 1998; Kerr and Stattin, 2000), and who have delinquent peers (Warr, 2002; Weerman, 2011). Furthermore, the nature of the activities that adolescents are engaged in and the type of settings they are exposed to, have been shown to affect their involvement in crime. Delinquent adolescents spend more time unsupervised with peers in unstructured activities (Miller, 2012; Osgood et al., 1996; Weerman et al., 2013). A critical test of the diversity hypothesis should thus include a measure of the exposure to criminogenic settings alongside a measure of setting diversity.

In sum, if hypothesis 1 is correct, an interesting follow-up question is whether the relation proposed in this hypothesis – the positive relation between *behavioral setting diversity* and delinquency – remains positive and substantial when the associations between delinquency and self-control, morality, peer delinquency, time spent unsupervised with peers, and parental supervision are taken into account. In other words: is there a relation between *behavioral setting diversity* and delinquency that is independent of these causal mechanisms that are known to be strongly related to delinquency, or is *behavioral setting diversity* merely a characteristic of adolescents who lack self-control, hold permissive moral attitudes to crime, have delinquent peers and spent unsupervised time with them, and who lack parental supervision? We believe that diversity in settings leads to an increase in crime opportunities, and therefore at least part of the association between delinquency and diversity is independent from these etiological variables. These arguments lead to the second hypothesis that we will test:

Hypothesis 2: The association between delinquency and geographic, functional and social *setting diversity* remains when the relations between delinquency and etiological variables of the individual and his or her parents and peers (self-control, morality, parental supervision, peer deviance, and unsupervised time with peers) are controlled for.

Data

Data were collected in a two-wave panel study among adolescents (843 in the first wave, 616 in the second) in the city of The Hague, a city with a population of 486,000 in 2009, and its neighboring suburbs.

Forty secondary schools in The Hague and its suburbs (the Netherlands) were approached with the request to allow recruitment of their students and holding interviews in school during school hours. Ten of these schools (25 percent) responded positively. In each school, all 1st graders (mainly aged 12–13 during the first wave) and 4th graders (aged 15–16 during the first wave)¹ were selected – altogether 942 adolescents. Below, the former group will be referred to as the ‘younger cohort’ and the latter as the ‘older cohort’. The parents were informed about the study and were asked to provide (passive) consent. From this population, 27 adolescents (2.9 percent) could not be reached because their school was too busy during the period of data collection; 15 adolescents (1.6 percent) did not participate in the study because their parents withdrew them from the study, 13 adolescents (1.4 percent) did not show up at the appointment, six (0.6 percent) moved to another home address, school or left school, and three

(0.3 percent) were ill during the data collection period. From the other 878 adolescents, 35 completed only one of the two data collection instruments that were used in this study. The remaining 843 respondents participated in the full study, completing both the *self-report questionnaire* and the *space-time budget interview* (these instruments are described below).

The retrieval rate in the second wave is 73 percent ($N = 616$). Non-response analysis showed that boys and the older cohort (the 4th graders during the first wave) had higher attrition rates, but delinquency rates measured during the first wave did not significantly differ between second wave respondents and non-respondents.

In the sample, 49.6 percent were from the younger cohort and 50.4 percent from the older cohort. Boys formed 55.0 percent of the sample and girls 45.0 percent. Ages ranged from 11 to 18 years old, with a median age of 14. Most respondents were 12/13 (younger cohort) or 15/16 years old (older cohort).

Two main research instruments were administered, a *space-time budget interview* and a *self-report questionnaire*. Both were very similar to those used in the Peterborough Adolescent and Young Adult Development Study, PADS (Wikström and Butterworth, 2006; Wikström et al., 2010, 2012). The main parts of the questionnaire and the space-time budget interview of the PADS were translated from English to Dutch, extended to include some additional concepts, and in a few instances adjusted to the Dutch situation. Both instruments were administered in schools during school hours by a group of well-trained research assistants (eight persons in the first wave and 14 persons in the second wave) and a fieldwork coordinator. Empty classrooms or other undisturbed locations were made available to administer the questionnaires and interviews (for one school, data collection took place in a meeting room of a nearby hotel). After completion of both instruments, respondents received an incentive for their participation: a voucher for the movies, worth €5 in the first wave and in the second wave €7.50 for respondents who participated in the study during school hours and €15 for respondents who participated in the study in their leisure time.

The first wave of the study started in October 2008 and was completed in May 2009. Two years later, the 616 adolescents that could be traced and that were willing to participate, again completed the same questionnaire and space-time budget interview. This second wave started in November 2010 and lasted until June 2011.

Space-time budget interview

The *space-time budget interview* is a structured personal interview that was conducted individually and face to face with the respondents. The instrument was originally developed by Wikström in the Peterborough Youth Study (Wikström and Butterworth, 2006) and refined in its successor, the Peterborough Adolescent Delinquency Study (Wikström et al., 2010, 2012). The instrument required approximately 45–50 minutes to administer. During the interview, activities of the adolescents during four recent days (4×24 hours) were recorded. These four days always included the previous Friday and Saturday and the two most recent working days, to ensure comparability of the data across the respondents (e.g. when the interview was on a Monday, the days covered were the previous Saturday, Friday, Thursday and Wednesday; when the interview was on a Thursday, the days covered were the previous Wednesday, Tuesday, Saturday and Friday).

Detailed information was collected about the activities of the adolescents for each hour of the day, including the nature of the main activity (e.g. sports, learning, sleeping), the function of the place where it took place (e.g. shop, school, friend's home, bar), the geographic location (geo-code on a map of The Hague), and the persons present in the setting (e.g. teacher, parent, peers, alone). In sum, the space-time budget interview recorded very detailed information about *where*, *when* and *what* respondents were doing *with whom*, during four days of the week before the interview. All four aspects (activities, places, locations and people) were recorded in great detail. For the activities, places and people present, hundreds of different codes were used.

Table 1 presents a stylized and fictive example of a part of a completed one-day *space-time budget interview*. In reality we used coded numbers, not literal descriptions, to represent activities, places and people present. For people present, we actually used separate columns for family, peers and other people.

The example records that the respondent woke up around 7am, delivered newspapers before she went to school and played soccer after school before returning home around 6pm where she had dinner with her parents and brother. In the evening the respondent did homework, performed 'non-social' activities on the computer ('digital' social activities were separately coded) and watched TV, in part with her brother and mother, before going to sleep around 11 pm.

To record the geographic locations of the respondents, a series of detailed colored maps of the city of The Hague were used. The maps were overlaid by a numbered grid of 200×200 meters, to help respondents communicate their whereabouts with great precision. The geocodes in Table 1 refer to the cells of this grid. Figure 1 displays, in gray tones, a small part of one of the maps.

Geographic, functional and social setting diversity

We hypothesize that the *diversity* of the settings that adolescents participate in, increases their exposure to criminal opportunities. Any measure of the diversity of the settings that the adolescents participated in, must depend on a definition of when two settings are different and when they are equal, and thus when the switch from the one to the other constitutes a setting change, and when not. This definition is based on the three constitutive aspects of settings that we distinguish, that is, the geographic, the functional and the social aspect.

The *geographic* aspect exclusively refers to the geographic location of the setting (e.g. AK31 in Figure 1), which is the grid cell where the adolescent reported being at a specific day and time. In line with this definition, a geographic setting change occurs only if the respondent reports having moved from a geographic location in one grid cell to a geographic location in another 200×200 meter grid cell. For example, if the respondent woke up at 7am, spent the next two hours at home and spent between 9am and 3pm at school (presuming school is not located in the same 200×200 meter grid as the home) the person is coded as making a geographic setting change from 8am to 9am. The geographic aspect of a setting is not sensitive to changes in functional place (schoolyard, home, street . . .) or social categories (with parents, with peers . . .), only to movements from one grid cell to another. In Figure 1, the person experiences four geographic setting changes (to AH34, to AD24, to AF25 and to AH32).

Table 1. Stylized and fictive completed space-time budget interview mapping one day.

Hour	Geocode	Function of place	Activity ^a	Others present
6	AH32	home	sleeping	none
7	AH32	home	personal care	mother
8	AH34	street	working	none
9	AD24	classroom	learning	classmates, teacher
10	AD24	classroom	learning	classmates, teacher
11	AD24	classroom	learning	classmates, teacher
12	AD24	classroom	learning	classmates, teacher
13	AD24	schoolyard	socializing	classmates
14	AD24	classroom	learning	classmates, teacher
15	AD24	classroom	learning	classmates, teacher
16	AF25	soccer field	playing soccer	teammates, trainer
17	AF25	soccer field	playing soccer	teammates, trainer
18	AH32	home	eating	brother, parents
19	AH32	home	doing homework	none
20	AH32	home	computer (non-social)	brother
21	AH32	home	watching TV	brother, mother
22	AH32	home	watching TV	mother
23	AH32	home	sleeping	none
...
5	AH32	home	sleeping	none

Note: ^aThe 'activity' column is part of the space-time budget interview, but its contents were not used in the analysis.

The *functional* aspect of a setting refers to the function of the place where the respondent was (e.g. soccer stadium, classroom), that is, to how it is normally used. A change in functional setting occurs if the respondent reports that he or she changed from one functional place to another (e.g. from the classroom to the schoolyard), or both. In Table 1, the person experiences six functional setting changes (to work on the street (e.g. delivering newspapers), to classroom, to schoolyard, to classroom, to soccer field, to home).

The *social* aspect of a setting refers to the set of persons present in a particular situation. In Table 1, the person experiences 12 social changes (to 'mother', to 'none', to 'classmates, teacher' ... to 'brother, mother', to 'mother', to 'none').

All setting changes are defined in terms of the categories in the space-time budget interview. For example, if the individual is playing soccer in the company of teammates and the soccer trainer, there would be a social setting change if the trainer were to leave and not be present in the next hour, but not if another a teammate left the group. This is because both 'trainer' and 'group of peers' are the social categories; a change in the composition of the latter group is not captured in the space-time budget interview.

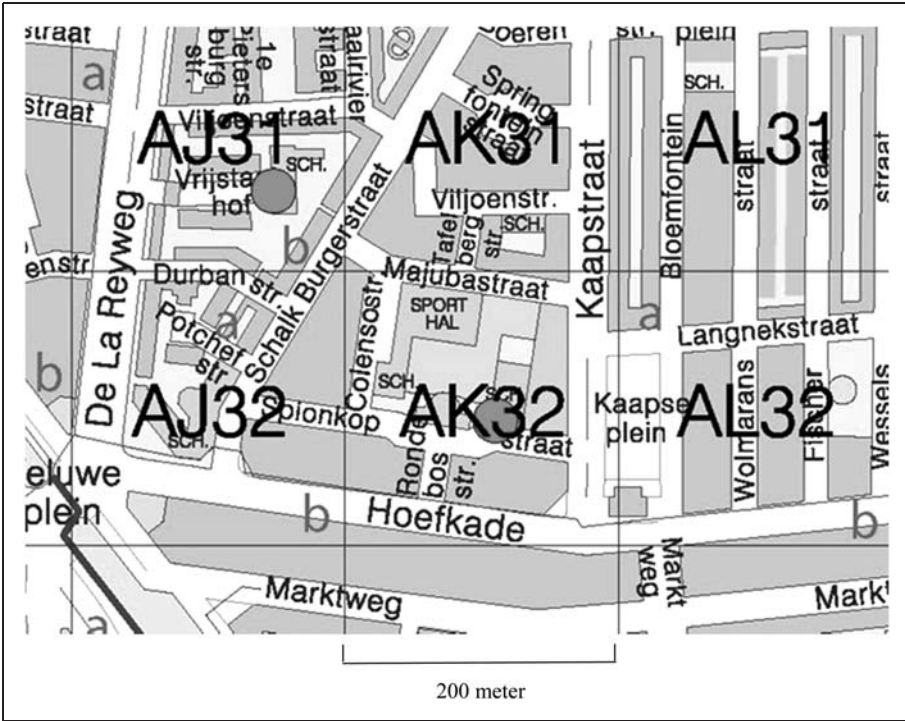


Figure 1. Detail of geocoding map (transformed to gray tones) used in the space-time budget interview.

Two measures of setting diversity: Change and heterogeneity

The geographic, functional and social diversity of adolescents’ exposure to settings was established with two different types of measure. The first type of measure, *setting changes*, is the most straightforward one. It simply counts the average number of setting changes that an adolescent experienced per day during the four days recorded. Because we distinguish three types of diversity (geographic, functional and social), we also analyze three change measures: geographic setting changes, functional setting changes and social setting changes.

The other measure, *setting heterogeneity*, is a standard measure of diversity in qualitative (categorical or nominal) variables, the index of qualitative variation (IQV; Agresti and Agresti, 1978). The IQV is also known in the literature as the Blau, Simpson or Herfindahl index. In our application, it can be interpreted as the likelihood that two hours randomly taken from the same day of the adolescent, were spent in a different setting. As depicted in the formula

$$SH = 1 - \frac{\left(\sum_{j=1}^J (h_j)^2\right)}{\left(\sum_{j=1}^J (h_j)\right)^2} = 1 - \frac{\sum_{j=1}^J h_j^2}{24^2}$$

where J is the total number of unique settings that the adolescent participated in during the day, and h_j is the total number of hours spend in setting j during the 24 hours of the day. Note that an adolescent who participated in only a single setting during the day has $SH=0$, while an adolescent who participated in a different setting every hour has $SH=23/24=0.96$. The IQV was averaged over the four days during which activities were recorded. Again, because we distinguish three types of diversity (geographic, functional and social), we also analyze three heterogeneity measures: geographic setting heterogeneity, functional setting heterogeneity and social setting heterogeneity.

Although both *setting changes* and *setting heterogeneity* measure the diversity of the settings that a person is exposed to, they measure different aspects of the diversity. The first measure, *setting changes*, is sensitive to the dynamic aspect of participation in settings. The second measure, *setting heterogeneity*, is more indicative for variation. For example, a person who moves five times from his or her home to a friend's home and back during the day, has made 10 functional setting changes, but has been in two functional settings only. Another person may have switched functional settings only five times (e.g. from home to school, to work, to leisure, to a friend and back home) but attended four different settings. The former person was more dynamic but less varied, the latter was more varied but less dynamic.

Figure 2 displays the distributions of the six variables constructed to measure setting diversity. The three upper figures display geographic, functional and social *setting changes*, respectively. These measures can logically vary between 0 and 23. The three figures in the lower part display geographic, functional and social *setting heterogeneity*.

Self-report questionnaire

In both waves, the *questionnaire* was administered in groups of four adolescents supervised by one research assistant during one school hour of 45–50 minutes. This relatively intensive supervision assured that adolescents were closely monitored, supported and stimulated, and that any questions or concerns that they had about the questionnaire could be addressed immediately. The procedure resulted in very low item non response (overall less than 1 percent).

In the present study, six variables were constructed from multiple items in the self-report questionnaire: delinquency, self-control, morality, parental supervision, peer deviance, and unsupervised peer activity.

All variables were measured in both waves. To reduce ambiguity about causal relations, in the present analysis the dependent variable is the delinquency measure of the second wave, while the independent variables are the other variables measured in the first wave.

All variables are summative scales, after having examined the latent structure using exploratory factor analysis (principal axis factoring). Although the item non-response was low (at its highest 2 percent), imputation to assign acceptable values to missing data (using the EM-method) was used to minimize loss of information.

Delinquency (wave 2) is a general frequency scale of adolescent offending. The 20 items measure how often during the preceding year the adolescents have been involved in serious and common offences, several kinds of violent behavior and the selling of drugs. Example items are 'stole a bicycle', 'robbed someone', 'kicked or hit somebody that got

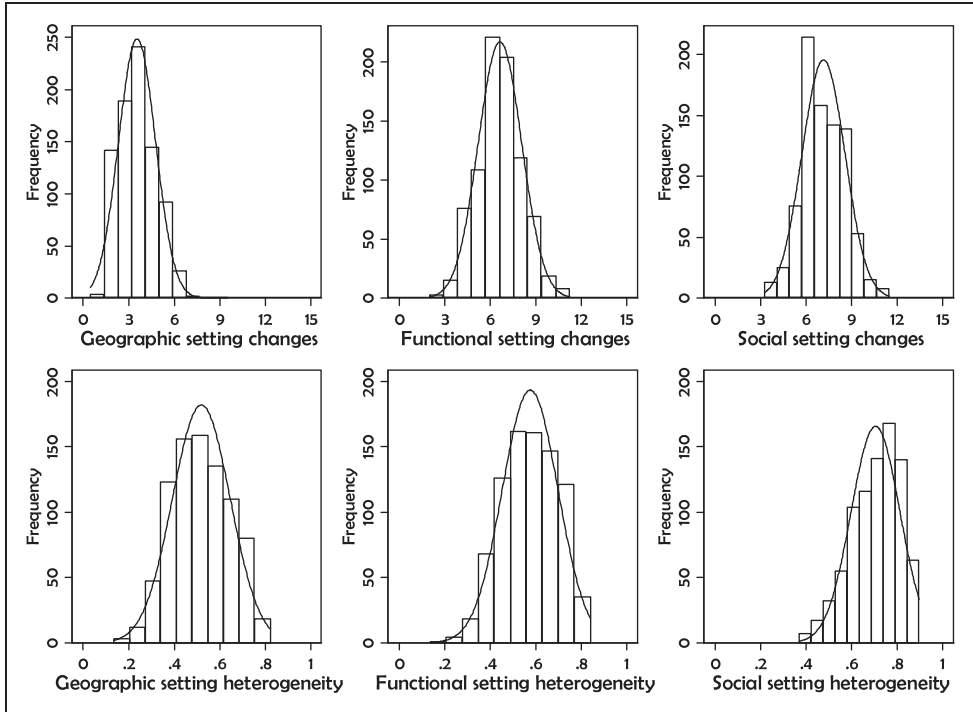


Figure 2. Numbers of geographic, functional and social setting changes (top row), and geographic, functional and social setting heterogeneity (bottom row): averages across four days, measured at T1.

injured as a result’, and ‘carried a knife or other weapon’. Answer categories are ‘never’, ‘once’, ‘twice’, ‘3–5 times’, ‘6–10 times’ and ‘more than 10 times’. The reliability measure (Cronbachs alpha) of the delinquency scale is .82. Because the distribution is positively skewed (right-skewed), the analyses are based on the square root transformation of the original metric, which reduces the skewness. Figure 3 displays the distribution of both the original variable and its square root.

Self-control (wave 1) measures one’s level of self-control, a latent construct of individual traits (Gottfredson and Hirschi, 1990). The scale is an additive index based on a 24-item scale that measured six dimensions of low self-control (Grasmick et al., 1993). It was shortened to a more concise index of 10 items. Example items are ‘If I want something, I do it immediately’, ‘I lose my temper easily’, ‘Sometimes I will take a risk just for the fun of it’ and ‘I often do things without thinking of the consequences’. Answer categories are ‘yes!’, ‘yes’, ‘yes/no’, ‘no’ and ‘no!’, indicating the range between full agreement and full disagreement. The alpha is .75. We reversed the original scale (which measures low self-control) so that high scores indicate high levels of self-control.

Morality (wave 1) measures the adolescent’s disapproval of moral rule breaking. High scores indicate high moral standards. The construct is an additive index of the respondent’s evaluation of 16 situations of potential wrong-doing. Example items include ‘ride a bike through red light’, ‘smoke cigarettes’, ‘paint graffiti on a house wall’ and ‘steal a CD

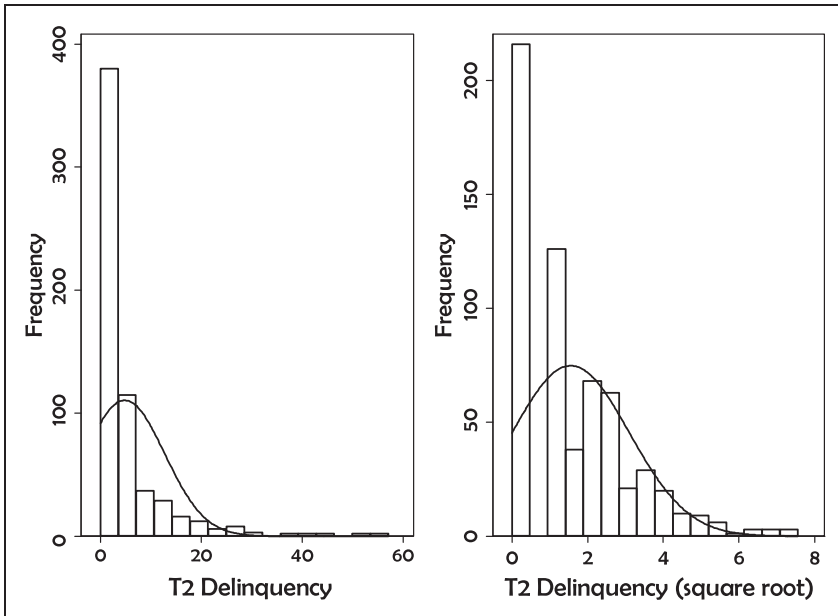


Figure 3. Delinquency (original and square root), measured at T2.

from a shop'. Answer categories are 'very wrong', 'wrong', 'a bit wrong' and 'not at all wrong'. The alpha is .91.

Parental supervision (wave 1) consists of three items that indicate how much of their whereabouts adolescents disclose to their parents. The items are 'Do your parents know where you are when out of home?', 'Do your parents know what you are doing?' and 'Do your parents know which friends you are hanging out with?' Answer categories are 'yes, always', 'mostly', 'sometimes' and '(almost) never'. The alpha of this scale is .76.

Deviance of peers (wave 1) measures the amount of delinquent and deviant behavior of peers as perceived by the adolescent. It is measured by six questions about how frequently respondents' peers offend, break rules and use drugs and alcohol. The items are 'How often do your friends skip school without an excuse?', 'How often do your friends get drunk?', 'How often do your friends use drugs?', 'How often do your friends steal from others or from shops?', 'How often do your friends destroy things that do not belong to them?' and 'How often do your friends beat up or get into fights with others?'. Answer categories are '(almost) never', 'sometimes', 'often (each month)' and 'very often (each week)'. The alpha is .82. This measure is based on the perceived behavior of peers. It is probably somewhat biased because respondents tend to impute or project their own behavior onto their peers, leading to an overestimation of the relation with their own delinquency (e.g. Rees and Pogarsky, 2011; Weerman and Smeenk, 2005)

Unsupervised peer activity (wave 1) indicates the amount of time that adolescents spend with their peers in the absence of adults. It is measured by three questions: 'How often do you hang out with your friends in the street, in squares or parks?', 'How often do you hang out with your friends in shopping malls or the city shopping center?' and 'How often do you spend time in the evenings with your friends in the centre

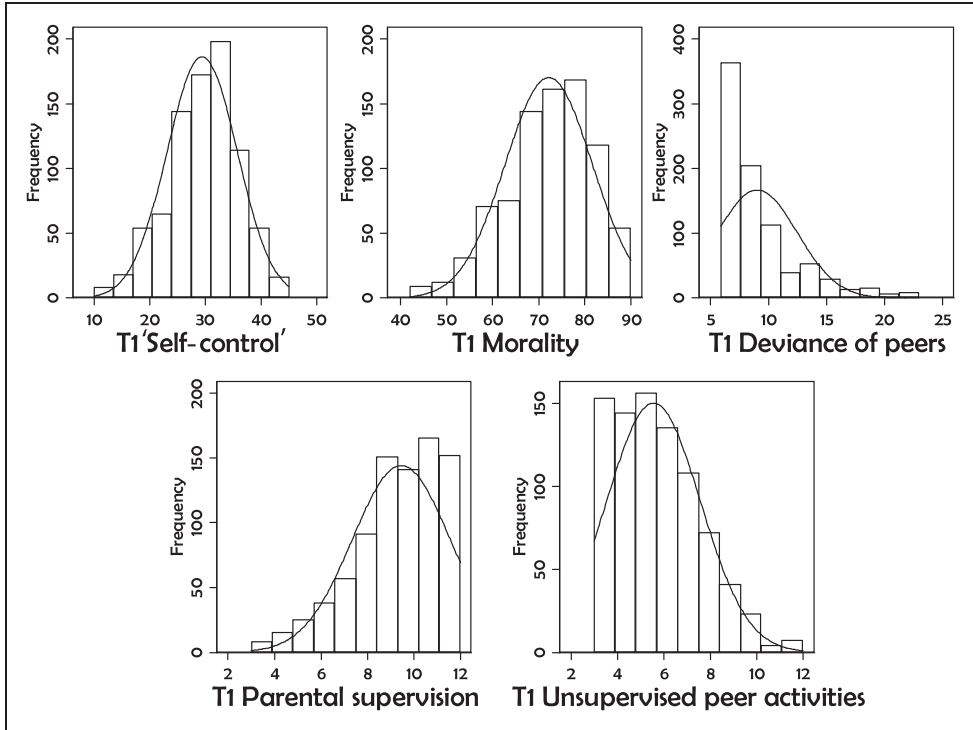


Figure 4. Self-control, morality, deviance of peers, parental supervision and unsupervised peer activities, measured at T1.

of The Hague?'. For each item, there were four answer categories: (almost) never, once or twice a week, several (3–5) days a week, (almost) every day. The alpha of this scale is .63.

Figure 4 presents the distributions of the scales of self-control, morality, parental supervision, deviance of peers and unsupervised peer activity. Although the distribution of parental supervision is left-skewed and the distributions of peer deviance and unsupervised peer activity are right-skewed, no transformations were made to these variables because of their exogenous roles in the analyses.

Analytical strategy

To test both hypotheses we utilize bivariate and multivariate regression analysis of delinquency as measured in the second wave of the research, while as independent variables we use only variables measured in the first wave. While this strategy is no guarantee for being able to claim causality, it assures at least that possible causal factors are measured in time before their hypothesized potential consequences. Thus, the variables we see as causes of delinquency were measured in 2008/2009, the delinquency measures we view as consequences are measured in the first wave in 2010/2011, but apply to the

period September 2009 to July 2010 because we asked respondents to report on delinquency during the past school year.

The ordinary least squares (OLS) regression model is not the ideal regression technique in this case, because various assumptions that underlie the OLS model are implausible given the skewed nature of the unconditional distribution of the original delinquency variable and its square root (see Figure 3). For example, the skewed distribution implies that residual variances will be higher at higher predicted levels of delinquency, while the OLS model assumes constant residual variance.

Osgood et al. (2002) proposed Tobit regression (also see Amemiya, 1984; Long, 1997; McDonald and Moffitt, 1980) as an alternative model for the analysis of self-reported delinquency. The Tobit regression model is a censored regression model in which the dependent variable (here: delinquency) is a latent variable of which the values at and beyond an upper or lower threshold are censored (in the case of delinquency there is a lower threshold at 0). Censoring means that the values of some observations are incompletely observed: what is known about these observations is that their real value is located at or below the cut-off point, but we do not exactly know where they are located).

Tobit regression was preferred to other analytical options (like weighted least squares regression and negative binomial regression) for theoretical and empirical reasons. Theoretically, the basic assumption of Tobit regression seems to fit the nature of delinquency. The assumption is that the dependent variable, here delinquency, is a latent characteristic that is normally distributed, but imperfectly measured because values below a certain threshold value on the latent characteristic cannot be measured. Respondents below the threshold, those who did not offend in the past school year, are a varied group of adolescents: some of them would almost never break the law or moral rules, others may have committed other and possibly less serious offenses than the specific ones listed in the questionnaire, or during another period.

Although the assumption of variability in the non-delinquent group cannot be tested with the available data, its plausibility is demonstrated by the fact that when individual items are removed from the 20-item scale, the size of the non-delinquent group always increases. This implies that the non-delinquent group has variability in delinquency because it contains individuals who checked the item that was just removed and individuals who did not.

Empirically, Tobit regression analysis appeared to fit the distribution of our dependent variable (when square root transformed) better than a negative binomial regression analysis or simple OLS. This was indicated by a comparison of the Akaike Information Criterion (AIC) for 'empty models', a goodness-of-fit measure that can be used to select the most appropriate model. Tobit regression with a square root transformation of the total offending scale was the model with the lowest AIC value among a number of alternative modeling strategies (OLS and negative binomial, log-transformed square root transformed or and untransformed delinquency).

Because by the design of our sample respondents are nested in schools, we report robust standard errors that are upwardly corrected for clustering by schools. Although random effects hierarchical Tobit models were also estimated, the estimates were almost indistinguishable from the ones we present below, which are the result of regular (non-hierarchical) Tobit analyses.

Before conducting the regression analyses, all independent variables except the control variables (sex and cohort) were standardized to facilitate a comparison of estimates. As mentioned, the dependent variable, total frequency of delinquency, was square root transformed to decrease its skewness (see Figure 3).

Given the sizeable correlations between some of the variables in the analysis (see Appendix) the potential for multicollinearity is present. Therefore, collinearity diagnostics were calculated for all models. For each model we estimated variation inflation factors (VIF) as well as condition numbers (Belsley, 1991a: 27). High VIF values, with a suggested bottom threshold value of 5 or sometimes 10, indicate serious multicollinearity problems. For the condition number, values above 30 have been suggested as indicating potentially serious collinearity (Belsley, 1991b). For each model, we report the mean and the highest VIF value and the condition number.

Whereas self-report questionnaires have a long history in criminological research, the space-time budget interview was only recently developed by Wikström, and has only been used before in the PADS + study (Wikström et al., 2010, 2012). The joint application of both instruments in the present study raises the issue of whether the four days measured in the space-time budget survey can be considered representative of longer periods. In other words: how typical are the four days covered in the space-time budget interview? For every day recorded in the space-time budget interview, the respondents were asked whether this was a 'typical' or a 'non-typical' weekday or Saturday, and for every non-typical day it was asked why it had been non-typical. The answers revealed that of the 2,464 days recorded (i.e. four days for each of the 616 respondents) only 2.6 percent were recorded as non-typical, mostly (1.7 percent) because the respondent had been ill and had stayed home. To verify that the measures based on the 2.6 percent non-typical days did not affect the outcomes, the analyses presented below were also performed leaving out the non-typical days. The results (not presented here) were almost indistinguishable from the results that include the non-typical days.

An opportunity for assessing the concurrent validity of the space-time budget interview is to consider the correspondence between the items measuring substance use in the space-time budget interview and similar measures in the self-report questionnaire. The questionnaire asked 'How often do you drink alcohol?' and 'How often do you smoke marijuana or hash?'. The answer categories were (1) 'never', (2) 'less than once a month', (3) 'once or a few times per month', (4) 'once or a few times per week' and (5) '(almost) daily'. As a first measure of correspondence, we considered the numbers of respondents that answered 'never' in the questionnaire but still reported substance use in the space-time budget interview. These respondents seem to provide inconsistent answers. In the first wave, of the 448 respondents who answered they never drank alcohol, four reported alcohol use in the space-time budget interview (0.89 percent). In the second wave this applied to four (1.75 percent) of the 229 respondents who answered they never drank alcohol. For cannabis use, the numbers were two (0.28 percent) of 712 in the first wave and three (0.63 percent) of 478 in the second wave. Clearly, these inconsistent answers are very rare. As a second measure of correspondence, we calculated Pearson product-moment correlation coefficients between the questionnaire items (coded 1–5) and space-time budget measures (number of days in which at least one hour involved reported alcohol or use cannabis use). These correlations were .65 and .70 for alcohol use in the first and second wave respectively, and .67 and .77 for cannabis use

in the first and second wave respectively. Taking into account that the space-time budget interview uses somewhat different metrics than the questionnaire, these correlations are substantial and may be seen as an indication that the days covered in the space-time budget interview may be considered representative.

Findings

Tables 2–4 summarize the results of both the bivariate and multivariate Tobit regression analyses. Table 2 utilizes the geographic setting diversity measures, Table 3 the functional setting diversity measures, and Table 4 the social diversity measures.

In each of these tables, our first hypothesis is tested in the bivariate models A and B. Models 2A, 3A and 4A regress delinquency on setting changes, models 2B, 3B and 4B on setting heterogeneity. Four of the six estimated coefficients (geographic and functional changes and geographic and functional heterogeneity) have a value around .45 and are significant. Social setting heterogeneity has an estimated (weakly significant) value of .20, while social setting changes is estimated .12 and is the only non-significant measure. The positive relation between delinquency and measures of setting diversity, in particular the geographic and functional measures, confirms the first hypothesis, which states that delinquent adolescents display more geographic, functional and social *diversity* in their daily routines than non-delinquent adolescents. The effect of social diversity appears weaker than those of geographic and functional diversity.

Table 2. Coefficients of Tobit regression analysis of (square root transformed) delinquency. Setting diversity based on geographical settings. Independent variables standardized (except for 'Girl' and 'Cohort'). Significance levels adjusted for clustering by school. N = 616 observations, of which 215 left-censored at 0 and 401 uncensored.

	2A	2B	2C	2D
Geographical setting changes	.45***		.22*	
Geographical setting heterogeneity		.41***		.24**
Self-control			-.42***	-.42***
Morality			-.28**	-.27**
Peer deviance			.20	.20
Parental supervision			-.07	-.07
Unsupervised peer activities			.14**	.15**
Girl (vs boy)			-.73***	-.75***
Older cohort (vs younger)			-.93***	-.96***
Highest VIF			1.87	1.87
Mean VIF			1.43	1.43
Condition number			8.85	8.93

* $p < .05$; ** $p < .01$; *** $p < .001$

Table 3. Coefficients of Tobit regression analysis of (square root transformed) delinquency. Setting diversity based on functional settings. Independent variables standardized (except for 'Girl' and 'Cohort'). Significance levels adjusted for clustering by school. N = 616 observations, of which 215 left-censored at 0 and 401 uncensored.

	3A	3B	3C	3D
Functional setting changes	.46***		.18*	
Functional setting heterogeneity		.46***		.25**
Self-control			-.42***	-.42***
Morality			-.28**	-.27**
Peer deviance			.20	.19
Parental supervision			-.08	-.07
Unsupervised peer activities			.15**	.14**
Girl (vs boy)			-.72***	-.74***
Older cohort (vs younger)			-.89***	-.98***
Highest VIF			1.87	1.87
Mean VIF			1.42	1.44
Condition number			8.83	8.87

* $p < .05$; ** $p < .01$; *** $p < .001$

Table 4. Coefficients of Tobit regression analysis of (square root transformed) delinquency. Setting diversity based on social settings. Independent variables standardized (except for 'Girl' and 'Cohort'). Significance levels adjusted for clustering by school. N = 616 observations, of which 215 left-censored at 0 and 401 uncensored.

	4A	4B	4C	4D
Social setting changes	.12		.04	
Social setting heterogeneity		.20*		.09
Self-control			-.43***	-.43***
Morality			-.29**	-.29**
Peer deviance			.20	.19
Parental supervision			-.08	-.08
Unsupervised peer activities			.17***	.16***
Girl (vs boy)			-.74***	-.76***
Older cohort (vs. younger)			-.86***	-.89***
Highest VIF			1.87	1.88
Mean VIF			1.41	1.43
Condition number			8.70	8.74

* $p < .05$; ** $p < .01$; *** $p < .001$

The second hypothesis states that the positive association between delinquency and setting diversity remains when the relations between delinquency and other variables (self-control, morality, parental supervision, peer deviance, unsupervised peer activities and sex and cohort) are controlled. This hypothesis is tested in models C and D, which extend models A and B with etiological variables (person, parents, peers) and control variables (sex and cohort).

Before evaluating the findings with respect to the second hypothesis, we first briefly review the estimates of the other variables in models C and D. Three of the five estimated coefficients representing etiological variables are highly significant and very stable across all models. In line with previous research, self-control (approximately $-.42$ in all models) and morality (approximately $-.28$) are negatively related to delinquency, and unsupervised peer activities (approximately $.15$) are positively related to delinquency. The relations with peer deviance (approximately $.20$) and parental monitoring (approximately $-.08$) are also stable across the models but are not significant.

Even when accounting for the relations between delinquency and these key etiological variables, we still find significant control variable coefficients for sex and cohort, in all six models. The estimates indicate that for given levels of self-control, morality, parental supervision, peer deviance and unsupervised peer activities, girls are still less delinquent than boys (approximately $-.77$) and adolescents of the older cohort grade are less delinquent than adolescents in the younger cohort (approximately $-.87$).

Having discussed the roles of the etiological and control variables in models C and D, we now turn to the assessment of the second hypothesis, which postulates that a positive association between delinquency and *setting diversity* remains when the relations between delinquency and the other variables are controlled. The evidence regarding this hypothesis is mixed. It is partially confirmed for the *setting heterogeneity* measures. In models D in Tables 2 (geographic heterogeneity) and 3 (functional heterogeneity), the estimated setting heterogeneity coefficient is positive and significant. In Table 4, the effect of social setting heterogeneity is small and insignificant. In the multivariate context of models D all heterogeneity coefficients are considerably smaller ($.24$, $.25$ and $.09$ for geographic, functional and social heterogeneity respectively) than in the bivariate context of models B (where they are $.41$, $.46$, and $.20$ respectively). This indicates that the setting heterogeneity variables share a substantial amount of variance with the etiological and control variables. However, confirming the hypothesis, geographic setting heterogeneity and functional setting heterogeneity are still positive and significant. Contrary to the hypothesis, the effect of social setting heterogeneity is not statistically significant.

The results are similar for the other setting diversity measure: *setting changes*. The geographic setting changes coefficient in model A is positive ($.45$) and significant. It drops to $.22$ in the multivariate model C (Table 2), but is still significant. Similarly, the functional setting diversity effect is $.46$ in Model A and drops to $.18$ in Model C. Both values are statistically significant. Again the effects of social setting diversity are not significant (models A and C in Table 4). This demonstrates that social setting diversity (either measured as setting changes or as setting heterogeneity) is not independently related with delinquency.

In the model outcomes presented in Tables 2–4 there are relative strong effects of sex and age. Specifically, girls were less delinquent than boys, and adolescents from the older

cohort (who were 17–18 years old during the second wave) were less delinquent than those from the younger cohort (who were 14–15 years old during the second wave). These relations also hold bivariately. While the lower delinquency of girls is in line with the literature, the lower delinquency level amongst the older age cohort may come as a surprise. The finding is in line, though, with some of the recent literature on the relation between age and offending. The most recent ISRD study reports a peak in self reported offending at the age of 16 in most countries (Junger-Tas et al., 2012), and a recent representative youth survey in the UK suggests that the peak in delinquency is already reached in the age group of 14–15 years (Roe and Ashe, 2008).

Conclusion and discussion

In the present study we proposed the hypothesis that geographic, functional and social *diversity (behavioral setting diversity)* in daily routines is related to delinquent behavior of adolescents. This hypothesis was built around the assumption that new criminal opportunities are unlikely to be encountered when the individual remains in a setting that is geographically, functionally and socially stable, but instead are more likely to be encountered when the individual moves in and out of different settings. Using both the number of setting changes and setting heterogeneity as alternative measures of diversity, the hypothesis was tested with etiological factors of persons, parents and peers (self-control, morality, peer deviance and parental supervision) and sex and cohort (1st versus 4th grade) as controls. The results demonstrate that all measures of setting diversity have a significant positive bivariate relation with delinquency, which confirms our first hypothesis.

The second hypothesis stated that the association between delinquency and *setting diversity* remains when etiological variables were entered as controls. This hypothesis was partially confirmed. In regression models where geographic, functional and social diversity were analyzed separately, geographic and functional diversity measures (*setting changes* and *setting heterogeneity*) were positively and significantly related to delinquency. This did not hold for the social diversity measures. A possible explanation for not finding an independent effect of social diversity is the format of the space-time budget interview. In the interview, for each hour it is recorded whether certain categories of people are present, but the actual composition of the set of people in the setting is not recorded. For example, if a respondent spent one hour with two male friends, the next hour with three other friends and the next hour in a large group of still other peers, all three hours will be coded equally (with peers, no family, no adults) and the diversity measures will not capture any social setting heterogeneity or social setting changes, although the changing composition of the respondent's peer group over these three hours has actually been considerable. This underestimation of diversity is more likely to occur for social aspects of settings than for geographic or functional aspects.

Furthermore, the data collected with the space-time budget interview have limited temporal detail. As compared to other time-use measurement instruments (see Harvey and Pentland, 2002), its temporal unit of measurement is a full hour, which implies that measures of activity, location, place function and other people present in the setting are aggregated over a full hour. Thus, for example, if respondents had been in multiple locations during the hour, they were asked to report the location where they spent

most time during that hour. This temporal aggregation must necessarily underestimate the amount of setting changes and might also underestimate the amount of setting heterogeneity. However, because there is no reason to expect that this underestimation applies differentially to respondents in our sample, we believe it does not endanger the conclusion that setting diversity is related to delinquency.

The focus of this study was a rather abstract theoretical construct, namely 'setting diversity', and the main hypothesis simply postulated that setting diversity (rather than the contents of the activities and the settings) is positively related to delinquency. Our finding that setting heterogeneity is positively related to delinquency did not require any reference to the criminogenic or 'conspicuous' nature of certain settings (as indicated by geographic location, place function or social category). Evidently, setting diversity provides only a very partial explanation, and additional concepts were required to explain variations in delinquency. In particular, our findings also confirm the strong relations between delinquency and well-corroborated etiological measures like self-control, morality, peer deviance, unsupervised activities with peers, and parental supervision. Nevertheless, it is notable and theoretically important that we still find a substantial association between delinquency and diversity, despite controlling for key correlates of delinquency.

At this point we should emphasize that the tests of our hypotheses are conservative. There are two reasons why the estimated effects are likely to be somewhat deflated. The first reason is that there is a relatively large time difference between the measurement of the independent variables (in the first wave) and the dependent variable (in the second wave). The second reason is that the space-time budget interview covers only four days, and might not be fully representative for a much longer period of time.

Finally, to truly test environmental theories of crime, in particular crime pattern theory and routine activity theory, it is not enough to assess the relation between the activity patterns of individuals and their overall delinquency. As demonstrated in recent work by Wikström and his colleagues (Wikström et al., 2010, 2012), it is possible to go one step further and measure offending behaviors in the space-time budget interview itself, relating the probability of offending to the locations, the places, the activities and presence of other people, as measured in the space-time budget interview. Diversity and change could also be incorporated in future research on this subject, for example by relating the offences recorded in the space-time budget interview not only to the settings in which they were committed, but also to settings that the individual was exposed to during previous hours, or to the number of hours s/he has already spent in the present setting.

As the findings presented above are the first to relate setting diversity to delinquency, it is much too early to be conclusive about practical implications. However, it may be worthwhile to just sketch a possible implication for daily routines in Dutch high schools. Currently, most high schools require both teachers and pupils to change classrooms every hour, which often also includes changes to the composition of the classes. As a consequence, hour after hour pupils are exposed to different teachers, classrooms and possibly also classmates. According to our findings, this situation is likely to induce more delinquent behavior (e.g. fights, vandalism, thefts) than alternative regimes that are characterized by less diversity for the pupils, for example a regime that would have the same pupils be part of the same class and be taught in the same classroom during

a single day, and that would require only the teachers and not the pupils to change classrooms every hour. Obviously, we are not advocating such a regime on the basis of a single study, rather we are sketching an example of the kind of practical issues that our findings may speak to if they were to be replicated in future research.

In ending we would like to emphasize that setting diversity need not only have detrimental effects. Quite to the contrary, adolescents who are exposed to a diverse array of geographic, functional and social settings might also benefit in various ways from this diversity.

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Notes

1. The 1st grade is similar to the 7th grade in the US; the 4th grade is similar to the 10th grade.

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