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# Macro and Micro Scale Spatial Variables and the Distribution of Residential Burglaries and Theft from Cars: An investigation of space and crime in the Dutch cities of Alkmaar and Gouda.

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## Abstract

At present, more is known about the physical features of those built environments that are associated with criminal opportunity than is known about the spatial characteristics of potential crime sites and the interface that these have with private and public space. Hence, in 2004-5 a research project was carried out in the Dutch towns of Alkmaar and Gouda that aimed to fill this gap in knowledge by describing the spatial attributes of crime sites and relating them to the geographical distribution of residential burglaries and thefts from cars<sup>1</sup>. The main task was to identify the spatial conditions of those places where burglaries and car thefts took place, in terms of both the configuration of the street grid at various spatial scales and the relationship between private and public space..Statistical analysis was used to pinpoint the relationship between crime risk and these aspects of spatial configuration.

**Keywords:** Space and crime, risk band analyses, angular analyses, inter-visibility, topological depth.

## 1. Urban space, targets and criminal opportunities.

For the past twenty years, urban policy makers have drawn on insights from environmental criminology in order to develop safer urban areas. These insights have been translated into practical preventative measures and have resulted in successful approaches such as the British programme Secured by Design, the Dutch Police Label Safe Housing and the preventative design of parking areas. It is now widely accepted that criminal opportunities can be limited by manipulating the physical characteristics of the built environment (López, 2005).

Current approaches and theories from environmental criminology focus on the physical features of targets rather than on the spatial configuration of the street grid and the spatial structure of the urban environment, particularly the relationship between private spaces and the public realm. However, even the criminological disciplines acknowledge that spatial, as well as physical factors may play a role in the way criminal incidents take place. Yet the spatial component is under-represented when it comes to crime control. Until recently, tools to address and quantify spatial characteristics were either altogether lacking or not commonly known in police practice.

During the last decade, the space syntax method developed by Bill Hillier and his colleagues at University College London (Hillier and Shu, 2000, Hillier and Sahbaz, 2005) has been applied in studies of crimes committed in built environments in the UK. The results show a clear correlation between the distribution of crime and the degree of spatial integration of the various streets within the urban environment. However, up to now micro-scale spatial variables, such as the proportion of windows that overlook the street, the number of front doors that give onto the street or the precise way in which the public domain relates to the private sphere, have not been considered in their studies. There is a gap in current knowledge about how objects or potential targets are placed in relationship to one another, regarding the spatial, configurational structure of the urban street network, emergent patterns of human behaviour and the geographical and temporal distribution of crime. Moreover, it remains unclear whether the findings of Hillier and his colleagues can be generalised, or whether they are peculiar to the UK situation.

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Between January 2004 and December 2005, an opportunity arose to apply the space syntax method within the context of space and crime research in the Netherlands, with financial support from the Dutch Police and Science Programme. This also provided an opportunity to develop micro-scale spatial tools that were relevant to the Dutch situation by studying in detail the spatial characteristics of those locations where crimes occurred and comparing them with the spatial characteristics of the urban street network. The inquiry consisted of three parts. In the first part, a space syntax analysis was carried out of the Dutch cities of Alkmaar and Gouda, comparing the distribution of thefts from cars and residential burglaries over a two years period. In the second part, a local area in each town was studied in more detail, taking into account micro scale spatial factors such as the 'topological depth' between private and public spaces, the density of building entrances, the inter-visibility of dwellings and the constitutedness of the street, as well as non-spatial factors like dwelling types and street form and function. These micro scale factors were then compared with the spatial characteristics of streets and crime sites at a macro level. The third part of the study consisted of a statistical analysis of the data. Correlations between the various spatial parameters were made and - by means of risk band analysis - related to the crime risks of similar street segments.

## **2. Environmental criminology and urbanism**

### **2.1. Insights from environmental criminology**

Environmental criminology assumes that some people are criminally motivated and focuses on the criminal event rather than the offender's motivation. The objective of environmental criminology is to identify patterns in where, when and how crimes occur and to use the geographical imagination to describe, understand and control criminal events (Brantingham & Brantingham 1981, p. 18-21). This involves studying the temporal and geographical distributions of criminal events, the location of crimes and the targets that are selected by offenders. The most influential contemporary theories in environmental criminology are the *rational choice*, the *routine activity* and the *crime pattern* theory. These theories not only provide insights into the geographical distribution of crimes, but also the spatial conditions that influence this distribution.

Rational choice theory addresses the question as to why criminals commit offences in some situations and not in others (Cornish & Clarke 1986). It therefore focuses on the individual's assessment of the criminal opportunities provided by specific situations or, in other words, his assessment of the possibilities to maximise gain and minimise risk. The offender's assessment of criminal opportunity is constrained by his limited knowledge of the situation. Nevertheless, he tries to make a fair assessment of the situation and will offend when he assumes that a specific situation represents a good chance for illicit gain, a high degree of accessibility and a low chance of getting caught.

As the routine activity theory suggests, a major part of human activity comprises recurrent and prevalent activities (Cohen & Felson 1979). Activities such as formalised work, commuting, leisure, social interaction and child rearing are often repeated over and over again with the same timing, rhythm and tempo. The structure of these everyday routine activities influences criminal opportunity and creates predictable situations upon which illegal behaviour feeds. Criminals take into account the availability of attractive targets and the structure of the activities of potential victims and guardians. They know that legal daily activities separate people from their personal property at given times and places. Likewise, criminals know how prevailing routine activities bring together different mixes of street users at various times of the day. The timing of work, shopping and recreation creates regular patterns of human behaviour which, in turn, produce regular patterns of criminal opportunity that influence the spatial and temporal behaviour of criminal offenders.

The crime pattern theory combines the ideas of rational choices and routine activities to provide an understanding of the geographical distribution of crime (Brantingham & Brantingham 1981, 1993 and 1995). This distribution is not random. Rather, it is clustered around the homes of offenders, the places they visit and the routes along which they travel. The locations about which an offender has specific environmental knowledge are called his 'awareness space'. This space includes the area where the offender's routine activities take place, such as the surroundings of his home, the places he visits for his work and leisure activities and the streets he uses when travelling from one known place to another. Inside the offender's awareness space there are several 'opportunity spaces', places perceived by the offender to contain attractive targets, which (in the perception of the offender) combine high value, low guardianship and high accessibility. The crime pattern theory postulates that offences are most likely to occur where opportunity spaces intersect with awareness spaces.

## **2.2. Insights from space syntax research**

Recently, urban and architectural researchers have provided evidence about the relationship between spatial configuration and the distribution of crime through the application of the space syntax method. Since the method is able to calculate a built environment's spatial properties (Hillier 1998), it becomes possible to correlate these properties with quantifiable crime data.

In general, the results from space syntax research are in line with the theories of situational criminology. The research has provided evidence that people use a predefined set of daily movement routines, as a consequence of which some routes are frequented more often than others. Space syntax is able to identify these routes and characterise their underlying spatial conditions. In this way, space syntax is able, for example, to show how segregated streets have more complex routes to all other streets in a city compared with integrated ones.

Space syntax research has shown that areas with segregated spaces, where urban grids are visually broken up and where few dwelling entrances constitute the streets, are often affected by crime and social misuse (Hillier & Shu 2000, p. 232). This is also the case in areas that have a poor correlation between connectivity and local and global integration, and in segregated areas that are many axial steps away from integrated streets so that the topological structure of the urban grid is relatively deep. The same studies clarify that spatial configuration generates public movement patterns that are, to some extent, predictable and lead to different levels of co-presence and co-awareness in the urban environment (Hillier et. al. 1993). For example, in a research project conducted in London, Valerie Alford identified the spatial features of different types of crime. As she concluded, different types of street crime take place in different kinds of space and criminal incidents and pedestrian flows are clearly linked (Alford 1996, p. 64 - 67).

In his PhD thesis *Housing Layout and Crime Vulnerability*, Chih-Feng Shu studied the correlation between the configuration and layout of housing estates and urban areas in the new town of Milton Keynes and the spatial distribution of property offences. Three different areas were investigated over a two-year period (Chih-Feng Shu 2000). His findings challenge some aspects of Oscar Newman's ideas of defensible space and territoriality (Newman 1972, 1980), but are very much in line with the environmental criminology theories reviewed earlier. According to Shu, property crime tends to take place in segregated urban areas, especially in culs-de-sac or enclosed clusters favoured by Oscar Newman. Shu's research differs from earlier research in that he provides detailed spatial studies on a diversity of residential areas with a wide range of different types of dwellings, streets, spatial and social composition.

More recently, Hillier and Sahbaz (2005) have shed further light on the relationship between space and crime by emphasizing the need to use crime risk rather than crime rate. However, in their view, calculating crime risk is only useful at higher levels of spatial aggregation such as wards or neighbourhoods. When studying crime at the street or street segment level, a logarithmic function between the crime risk and the number of crimes committed can be found. This distortion can be compensated for by normalising the crime risk, by a process of aggregation. This involves taking all of the street segments in an area that have a given number of targets (dwellings, metres of street) and counting all the crimes (burglaries, robberies) committed on those segments, and then dividing the total crimes into the total targets to give a true crime rate at the aggregate level. (Hillier & Sahbaz, 2005).

In the research that follows, the methods and insights from environmental criminology have been combined with those originating from a configurational approach, and applied in a study of the Dutch cities of Alkmaar and Gouda. The routine activity and crime pattern theories were used to identify where and when awareness and opportunity spaces for residential burglars coincided. The space syntax method was used to identify and measure the spatial and configurational features of these particular places. As the results show, most residential burglaries took place in the most segregated and unconstituted streets that lay within a radius of 2.1 km from a burglar's home address (López 2005, Van Nes 2005). However, the level of integration and constitutedness were not unrelated to other spatial characteristics. In fact they were highly interdependent and correlated with other spatial characteristics of the built environment and with social factors as well. Therefore, these spatial aspects have been investigated in greater detail in the current study.

### 3. The method

Two approaches were used when carrying out the spatial analysis. The first approach calculated the spatial integration of the street grids of the two cities at various scales and compared the quantified macro spatial variables with crime distribution over a two year period. In the second approach, one local area in each town was investigated in greater detail. For every street segment in these local areas, twenty-five different micro spatial variables were recorded. Afterwards, a statistical analysis of the data was undertaken. Risk band analysis was used (Hillier & Sahbaz, 2005) to analyse the relationship between the observed micro spatial variables, the calculated macro spatial variables and the recorded distributions of crime.

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At the time of the study, no tried and tested methods were available for analysing the spatial relationship between private and public spaces in urban environments. Therefore, tools of this kind were constructed during this inquiry. The results of these various analyses have been presented here in two ways. First the results on the relationship between crime distribution and spatial configuration have been plotted on maps of each city. Second the results from the statistical analysis have been presented in scattergrams.

#### 3.1 The data

The police offices of Hollands-Midden and Noord-Holland-Noord provided detailed data for each residential burglary in terms of when it took place, the point of entry (from which side of the house), and the exact address of the burgled home. With regard to theft from cars, data on each car's location and the time of the break-in were provided. At the macro scale, a total of 1,988 residential burglaries and 7,785 thefts from cars have been analysed. These offences were reported to and recorded by the police during the period 2003 and 2004<sup>ii</sup>. Both completed and attempted offences were studied.

In order to reveal the micro spatial conditions for crime, one local area in each city was studied in greater detail. In Alkmaar the study was focused on De Hoef. In Gouda, the area consisted of the neighbourhoods Kadebuurt, Kort Haarlem, Vreewijk and Oosterwei. These two local areas

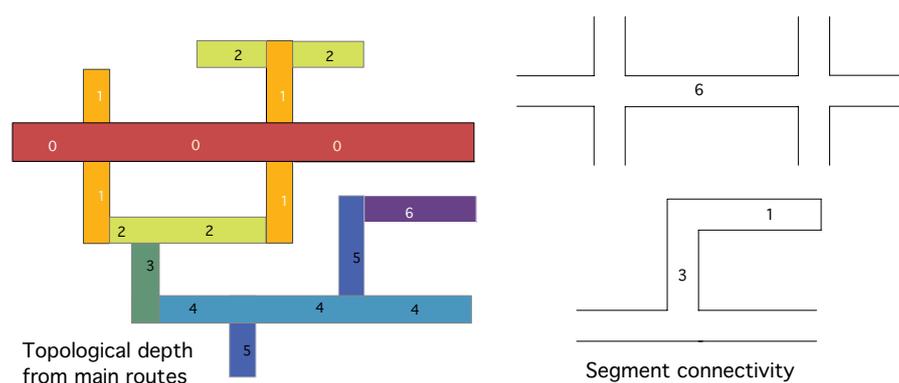
were chosen because of their large variation in terms of both the social composition of residents and their spatial set-up. Socio-economic information about the types of inhabitants living on each street segment were omitted from the study, due to the unavailability of detailed data of this kind.

### 3.2. The macro scale analysis

The macro scale analysis reported here addressed the question as to how each street or street segment in the two cities under investigation related both to others in the immediate vicinity and to the city as a whole. The following dynamic spatial measurements were calculated and taken into account: global integration, local integration and local angular integration (used to identify the main routes through the cities). These spatial variables were analysed using Depthmap software (Turner, 2004). The following static spatial measures were also taken into account: topological depth from the main routes, street connectivity and segment connectivity.

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The topological depth of each street (or street segment), defined as the number of direction changes it was away from the main routes of the city, was calculated manually, as follows. First, the main routes were identified by local angular analysis using the Depthmap software. By comparing angular choice based on geometric distance with topological distance and selecting those streets where the values for both measures were high, it was possible to identify the main routes in local areas and throughout the whole city. Various radii (for example, radius 3 with radius 8) were explored, in order to identify and select the main routes, and hence the route network, in a consistent way. After the main routes had been identified and drawn on a map of the city, the topological depth of the remaining streets (or segments) was calculated by counting the least number of changes in direction to get from each to the nearest main road. For each step, a colour code was given. Figure 1 (left) illustrates how this process was carried out.



**Figure 1: How the topological depth from main routes (left) and segment connectivity (right) is registered**

Segment connectivity, which relates to access and egress and indicates the number of possible escape routes from any given segment, was arrived at by counting the number of connections of each street segment. This is also a way to quantify the difference between grid-like and tree-like street layouts (Hillier & Sahbaz 2005). Figure 1 (right) illustrates how the calculation of segment connectivity was carried out.

### 3.3. Micro scale spatial relationships

In urban studies, a micro scale analysis normally focuses on the spatial relationships that hold between built forms (buildings and open spaces) and their adjacent street segments. Most built forms contain private spaces. Therefore, a micro scale analysis is especially useful to study the configurational relationships that exist between private and public spaces. Micro scale configurational relationships cannot, at present, be processed through computer software like the axial and angular analyses described earlier. Hence, each micro scale characteristic was observed on site and recorded in a manner that was amenable to statistical analysis.

During visual observations, 25 different features were recorded in 1,168 different street segments. The number of burglaries and thefts from cars was also plotted for each street segment. For each street segment the street name, the relevant house numbers and the age of the buildings were also noted. The number of potential targets on each segment was assessed by counting the number of dwellings, parking places, shops, cafés or pubs, and other buildings<sup>iii</sup>.

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The following private-public spatial relationships were taken into account:

- o The *topological depth* between private and public spaces;
- o The *density* of building entrances;
- o The amount of *constitutedness* of streets by building entrances;
- o *Street* function;
- o Dwelling *types*;
- o The degree of *territoriality* of the street;
- o The street *form*, in order to describe the mode of transport suitable for the street as well as the spatial possibilities for a perpetrator's escape;
- o The extent of *inter-visibility* between a street and its neighbouring houses.

An easy way to record the *topological depth* between private and public space is to count the number of semi-private and semi-public spaces one has to walk through to get from a private space to the nearest public street (Hillier and Hanson 1984, p. 102). If an entrance is directly connected to a public street, it has no spaces intervening between private and public space, so that the depth is equivalent to zero. If there is a small front garden between the entrance and the public street, the depth value is one, since there is one space between the closed private space and the street. If the entrance is located on the side of the house and it either has a front garden or it is hidden behind hedges or fences, then the topological depth of the entrance has a value of two. Entrances from back alleys hidden behind a shed have a value of three. Entrances into flats can be similarly represented, depending on the nature of the permeability between the private space and the street.

The *density* of building entrances simply records the number of entrances per unit of metric distance along the street, but syntactically speaking, a street's *constitutedness* depends on how the building entrances are connected to the street. This measure captures the adjacency and permeability

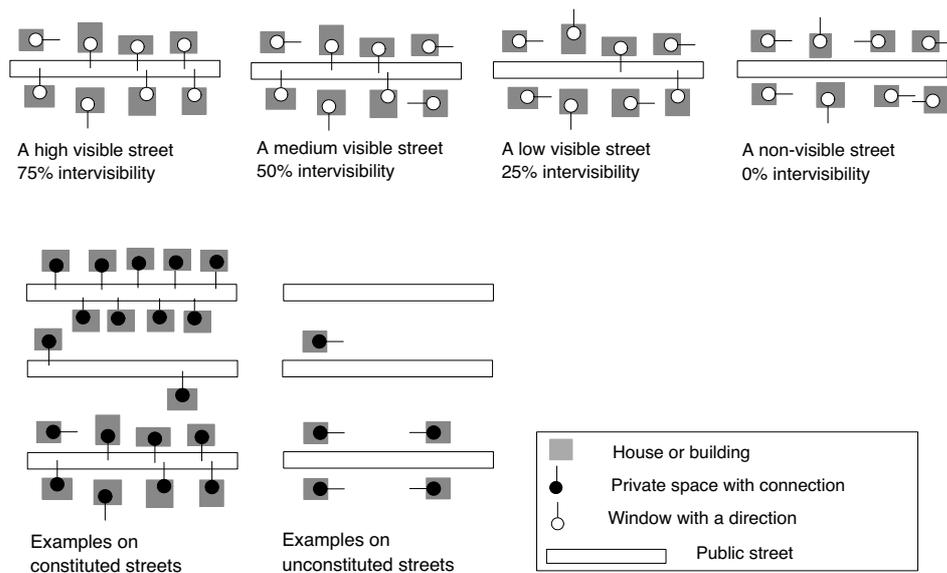
between buildings and public space (Hillier and Hanson 1994, p. 92). When a building is directly accessible to a street, then it constitutes the street. Conversely, when buildings are adjacent to a street but their entrances are not directly accessible, then the street is unconstituted. A street segment is regarded as constituted even if only one entrance is directly connected to the street, but if all the entrances are hidden behind high fences or hedges, or located on the side of the buildings, then the street is regarded as unconstituted. Figure 2 shows diagrams that illustrate a range of possible inter-visibility and constitutedness/unconstitutedness relationships.

To arrive at a definition of street *function*, a classification derived from the Dutch Ministry of Housing, Spatial Planning and the Environment (VROM) was used. VROM proposed the following classification: shopping street, urban traffic road, dwelling (upper floor) and office (ground floor) street, mixed household dwelling street in urban areas, flats in green areas, run down area street, family dwelling street in urban areas, dwelling and offices in low rise buildings street, low rise buildings along footpath, family dwelling street in green areas and detached housing. The classification therefore relates more to the type of area where the streets are located, rather than to the street function itself. The classification turned out to be crude and unsuitable for studies on urban safety and crime. Some streets could fit under several categories, while others did not fit under any of them. As one might expect, no significant correlations were found between VROM's functional street classification and crime distributions in the two cities.

With regard to dwelling *types*, low-rise dwellings were divided into row houses, detached houses, and semi-detached houses, whereas the high-rise dwellings were categorised as either apartment buildings, maisonettes, or flats. The number of floors of those buildings that were made up of flats was recorded.

During the on-site observations, the degree of *territoriality* of the different street segments was taken into account. Although this was a rather subjective variable, it was usually easy to feel that the degree of territoriality of public streets was low, whilst that of semi-private back alleys was high. Semi-public back alleys were more difficult to classify. Hence, they were considered to have a medium degree of territoriality. In line with Shu (2000, p. 115-117), street *form* was categorised as being either: a vehicular thoroughfare, a vehicular cul-de-sac, a pedestrianised street, a cul-de-sac driveway, a through footpath, a cul-de-sac front footpaths or a cul-de-sac back alley.

Finally, the extent of *inter-visibility* among neighbouring houses was measured by counting the number of doors visible from the door to each house, divided by the total number of houses in each street segment. The same procedure was done with respect to the number of windows and parking lots visible from dwellings. As it turned out, there was a strong correlation between inter-visibility from windows and the distribution of burglaries on a street.



**Figure 2: Diagrams showing various degrees of inter-visibility and the constitutedness - unconstitutedness relationship between buildings and streets**

#### 4. Interpreting the axial maps

All recorded criminal incidents were plotted on the axial maps of the two cities and compared with the distribution of the spatial variables. In the local areas, the burglar's point of entry and every back alley were recorded in detail. The strongest visual correlation was found between the topological depth from main routes and the distribution of burglaries. There was also a correlation between local integration and the distribution of burglaries.

Figure 3 shows the topological depth from Alkmaar and Gouda's main routes and all recorded residential burglaries. The map suggests that most burglaries take place in the topologically deeper streets.

There was also a visual association between local integration and the distribution of burglaries. As Figure 4 of Alkmaar and Gouda shows, residential burglaries were more common in the locally more segregated streets than in the more integrated streets.

The degree of constitutedness and the inter-visibility between doors and windows also influenced burglary rates. Since no software has been developed for calculating micro scale spatial relationships, these were done manually and the variables were visualised on a map. Figure 5 shows the degree of inter-visibility between windows in Alkmaar and Gouda's local areas and the distribution of burglaries, while Figure 6 shows the degree of constitutedness and the distribution of burglaries for the same areas.

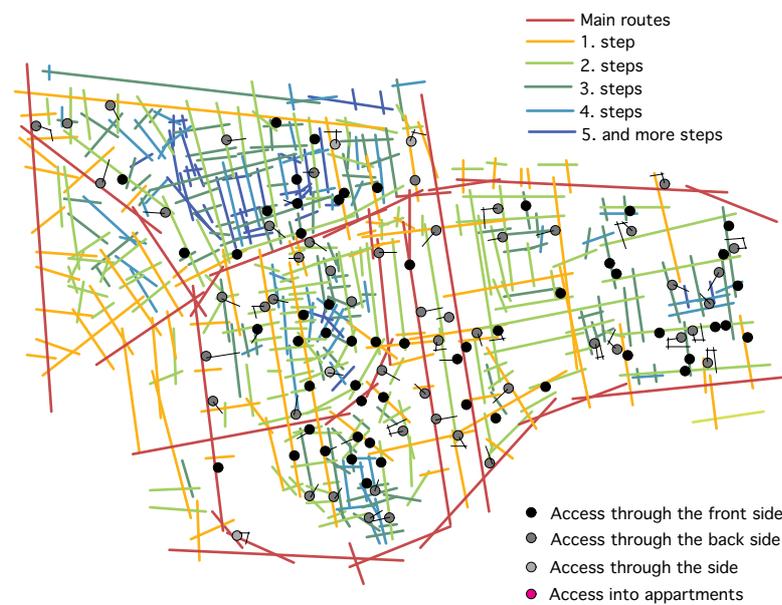


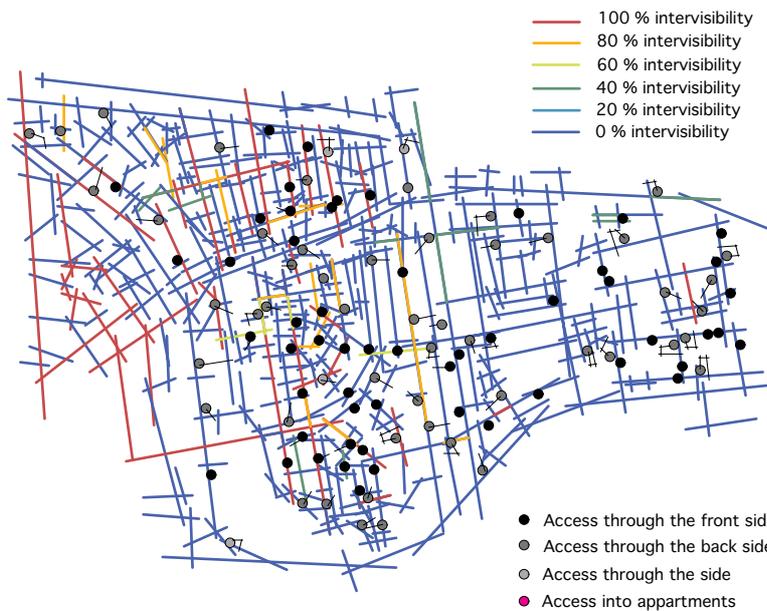
Figure 3: Topological depth from main routes from Alkmaar (above) and Gouda (below) with the dispersal of burglaries



**Figure 4:** Local integration in a local neighbourhood in Alkmaar (above) and Gounda (below) with the dispersal of burglaries



- Access through the front
  - Access through the back
  - Access through the side
  - Access into apartment
- 
- 100 % intervisibility
  - 80 % intervisibility
  - 60 % intervisibility
  - 40 % intervisibility
  - 20 % intervisibility
  - 0 % intervisibility



- 100 % intervisibility
- 80 % intervisibility
- 60 % intervisibility
- 40 % intervisibility
- 20 % intervisibility
- 0 % intervisibility

- Access through the front side
- Access through the back side
- Access through the side
- Access into apartments

Figure 5: Various degrees of intervisibility in streets in Alkmaar (above) and Gouda (below) with the dispersal of burglaries

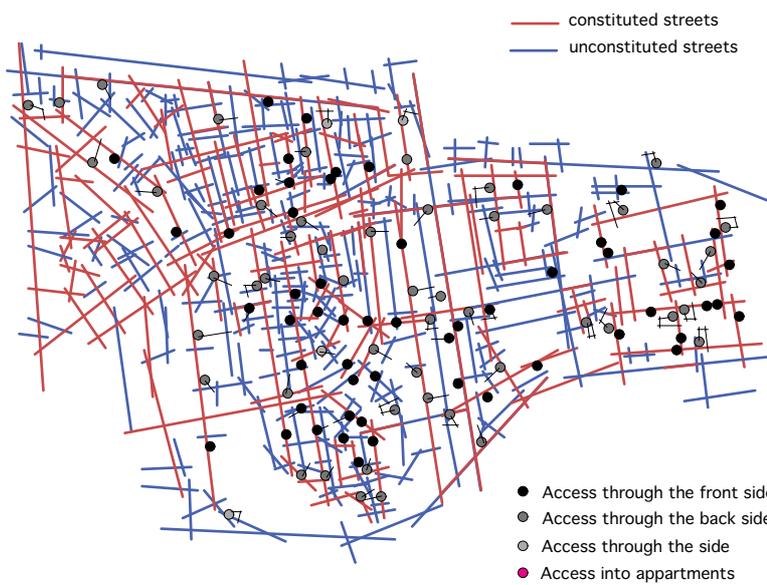
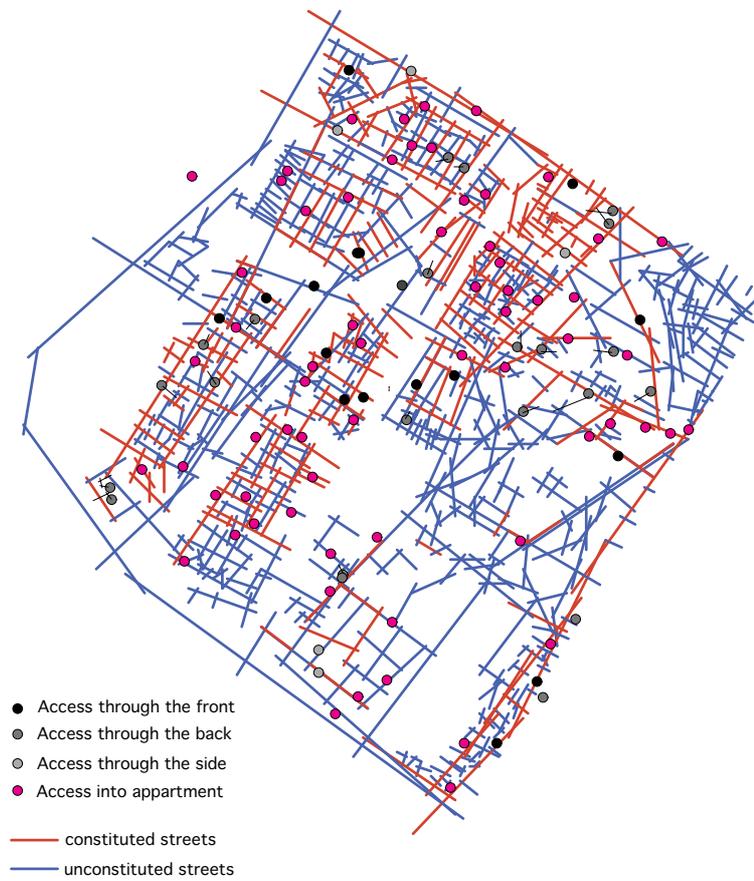


Figure 6: Constituted and un-constituted streets in Alkmaar (above) and Gouda (below) with the dispersal of burglaries

In Figure 5, the black lines illustrate 100% visibility, the dark grey lines illustrate 80% visibility, the grey lines illustrate 60% visibility, and so on. The very light grey lines show 0% inter-visibility. In Figure 6, the black lines show the constituted streets, while the light grey colour marks the unconstituted streets. The grey lines represent the intermediate cases.

A visual interpretation of axial maps gives an impression of possible relationships. However, it is by no means a reliable source for conclusions, since the visual analysis does not show the number of targets located along the axial lines. Some streets have no homes, while others have several. In this respect, statistical analysis is helpful in demonstrating more precise correlations between the various spatial measures, the distribution of crimes and the number of targets.

### **5. The statistical analysis**

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Statistical analysis is beneficial in that precise numerical evidence can be provided for hypothesis testing. In order to reveal the significance of the qualitative findings reported above, crime risks were calculated and a risk band analysis was conducted according to the method developed by Hillier and Sahbaz (2005). With a total number of 1,168 street segments, there was sufficient material to carry out such an analysis

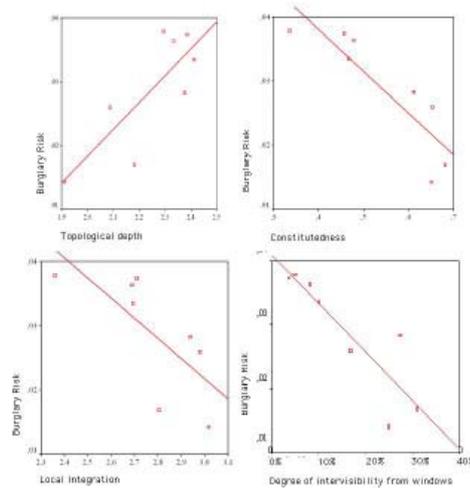
A risk band analysis consists of clustering street segments with the same number of dwellings and analysing the correlations between the different variables in relation to the different risk bands. The data were thus aggregated by focusing on the number of targets per street segment. In this way street segments with only one dwelling were clustered, as were segments with two dwellings, those with three dwellings, and so on. In order to make sure that the number of analysed units was not too small, they were unified to form larger risk bands so that the risk bands were comparable in size. By using risk bands the crime risk in every street segment was normalised by the number of objects. At the same time, the unit of analysis was no longer the street segment, but the risk band. In the analyses of Alkmaar and Gouda, eight bands were made, which comprised street segments with 1 - 4 dwellings, 5 and 6 dwellings, 7 and 8 dwellings, 9 and 10 dwellings, 11 - 15 dwellings, 16 - 20 dwellings, 21 - 40 dwellings and more than 40 dwellings.

Nearly all the investigated spatial variables showed (strong) correlations with the risks of residential burglary and theft from cars. The only exception to this was street function. The spatial parameters did not only correlate with the crime risks, but also with one another.

#### **5.1. Residential burglaries**

Figure 7 shows scattergrams of the relationship between the normalised burglary risk and three significant spatial variables. There was a linear correlation between burglary risk and a street segment's topological depth ( $R^2 = 0.64$ ,  $\text{sign.} = .016$ ). Apparently, chances of residential burglary increased the further away one was from the main routes through urban areas. The relationship between burglary

risk and constitutedness was also linear. This variable explained 77% of the variance in the examples studied (sign= .004). The higher the level of unconstitutedness, the higher the burglary risk. The last graphic shows the relationship between the normalised burglary risk and local integration. Here too, a weaker but significant correlation was found ( $R^2= 0.43$ , sign.= .044). In the two cities that were studied, locally segregated street segments apparently carried a higher burglary risk than the locally integrated ones.

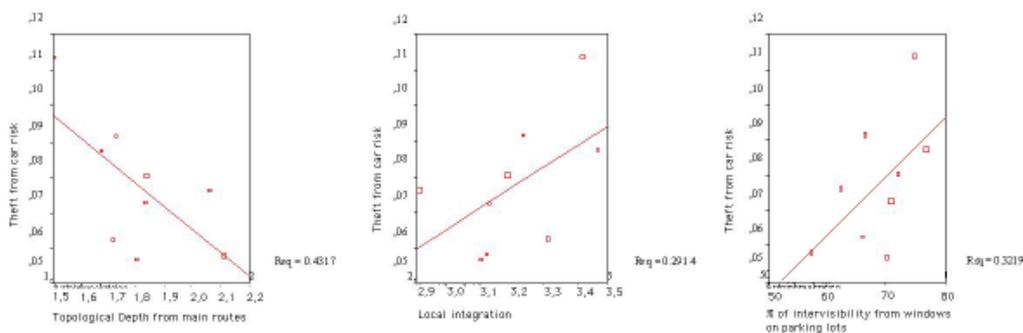


**Figure 7: Statistical correlations between burglary risk and various spatial parameters**

The degree of inter-visibility between windows also influenced a street segment's risk of residential burglary. The higher the amount of inter-visibility between windows (the percentage of windows visible from other windows in a street segment), the lower the chances of residential burglary. This was a strong and significant correlation ( $R^2= 0.77$ , sign.= .004).

### 5.2. Theft from Cars

As regards theft from cars, correlations between the crime risk and the spatial characteristics of the street segments were also found. However, these relationships were not as impressive as those for residential burglary<sup>iv</sup>. The topological depth of a street segment explained 43% of the variance in the risk of theft from cars. There were also linear relationships with the other spatial characteristics, such as local integration and the inter-visibility of parking places.



**Figure 8: Statistical correlations between theft from cars risk and various spatial parameters**

The correlation between the normalised risk of theft from cars and topological depth was reversed in comparison with residential burglary. The closer one parked a car to the main routes, the higher the chances were for victimisation. Likewise, the correlation between theft from cars and local integration was reversed in comparison with residential burglary. The higher the local integration values, the higher the risk of theft from cars. Offenders stealing from cars apparently had a different spatial behaviour than residential burglars. Residential burglars tended to target quiet streets, while car burglars seemed to prefer streets with high pedestrian and vehicular flow rates. Main routes tended to offer opportunities for anonymity and many escape routes, even though the social control was high, and the result may also have been influenced by the fact that the sound made when breaking open a car door or window disappeared in streets that had a high level of traffic noise.

One might expect that the higher the inter-visibility between cars and dwellings, the lower the risk of theft from cars. However, the opposite turned out to be the case. Apparently, car burglars felt relatively safe in the tumultuous environment of the main street. They were able to blend in with the crowd and commit their offences quickly with a low chance of being noticed.

### **5.3. The inter-relationship of spatial variables**

The spatial variables did not just correlate with crime risks, they were also inter-related. Especially, a street segment's topological depth from main routes appeared to give a good 'summary' of the various spatial characteristics of the street segment. When this factor was compared with the various other spatial characteristics (both at the micro and the macro level) then correlations emerged that were both significant and linear. In more than one way, topologically deep street segments seemed to possess characteristics that were the opposite of segments that were topologically shallow.

Segments with a topological depth of 0 or 1 were generally vehicular thoroughfares, while segments with a depth of 4 and higher were more often pedestrian-based (footpaths and back alleys). Commercial buildings such as shops, cafés and offices were usually located along the main roads (depth=0) or around the main road's corner (depth=1). Dwellings on the main road often had a direct connection to the street, while dwellings on segments with a higher topological depth were more often shielded by gardens, fences and hedges. Topologically deep segments generally showed lower local and global integration values, lower line and segment connectivity and lower control values. The higher the topological depth, the higher the degree of territoriality. Unconstituted segments were generally found in the deeper street segments.

## **6. Discussion**

This study found that there was a clear relation between the distribution of both residential burglaries and thefts from cars and the spatial configuration of the street net. This correlation appeared in respect of all of the investigated spatial variables with the exception of street functions. Moreover, the various spatial variables were also interdependent on one another. The dominant factor that explained both the variation in the spatial variables and the difference in the distribution of criminal incidents

was the *topological depth* of a street segment, relative to the main route system through the urban areas. This gave a concise picture of the spatial set up of an urban area, including an indication of the city's flow of human movement, both pedestrian and vehicular, as well as it showing a significant statistical correlation with the micro spatial parameters of targets and the distribution of residential burglaries and theft from cars.

When compared with the few but important studies carried out in the UK, this inquiry's outcome agreed with most of their results but the results from this inquiry broke new ground with respect to previous similar inquiries, in the way that angular route choice and the topological depth from main routes were taken into account. In Shu's research on three UK towns, burglary risk decreased with the number of inter-visible neighbours on the axial line unit. In the case of Alkmaar and Gouda, it decreased with respect to the number on the segment unit. Like in Hillier and Sahbaz's risk band analyses, crime vulnerability was high in street segments with a small number of buildings, in particular in cul-de-sac streets. As Hillier and Sahbaz postulate, dwellings connected directly to streets make streets safe. However, precise micro scale spatial analysis tools regarding the relationship between dwelling and streets were missing in their studies. Alford (1996) states that different types of crime take place in different kinds of space and that criminal incidents and pedestrian flows are linked. This was found to be the case in Alkmaar and Gouda, but here the relationship between topological depth, local integration and inter-visibility and crime risk were reversed with respect to residential burglary and theft from cars.

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## **7. Bridging the gap between environmental criminology and urbanism**

At present, there is a faint connection between the urban and environmental criminological disciplines (López 2005). Both disciplines have common subjects and common interests, but the connection is rarely made. Interdisciplinary research projects enhance mutual understanding by drawing attention to the relevance of criminal opportunities and the importance of a built environment's spatial set up in unveiling the complex relationship between the spatial configuration of the street network and the distribution of residential burglary and theft from cars. This relationship need not be merely assumed, but can now be measured and quantified. A configurational approach can measure and quantify the fine-grained spatial structure of a built environment's awareness space and opportunity space. What is now needed is more research in order to gain sufficient evidence to develop sound crime prevention strategies. Both the police and environmental criminology can gain from these insights. By addressing spatial characteristics, criminologists can open up ways to improve understanding on the relationship between space and crime and formulate better ways to control crime.

To what extent, then, can criminal opportunity be limited by the application of spatial measures? This question is difficult to answer, if only because social, physical and spatial factors are often inter-related. Interdependence between spatial factors also seems to play a significant role in the way built environments can be made safe, by considering various degrees of adjacency, permeability and inter-visibility at different urban scales. However, this inquiry has taken the first steps to gain new

insights into how crime distribution may relate to spatial properties. It has provided some simple tools to describe the spatial properties of crime vulnerably in urban areas. Further research still needs to be done before it will become possible to improve, revise and upgrade existing crime prevention programmes such as the British programme Secured by Design, the Dutch Police Label Safe Housing and the preventive design of parking areas, but in the not too distant future it may be possible not only to set physical standards for the design of the built environment, but also to specify in more detail the spatial configuration of a safer street network, including setting standards for the relationships of inter-visibility and constitutedness between buildings and public space and the degree of social control of the street from buildings.

## 8. Notes

- <sup>i</sup> This study was conducted as a joint project between the Dutch consultancy RCM-advies, the Section of Urban Renewal and Management, Faculty of Architecture of the Delft University of Technology and the police forces of Noord-Holland-Noord and Hollands-Midden. The *Dutch Police and Science Programme* provided financial support for the study (PW/OC/2005/17).
- <sup>ii</sup> Both completed and attempted offences were studied. In Alkmaar 958 completed and 104 attempted residential burglaries were recorded. In Gouda these were 704 respectively 222. The recorded number of completed thefts from cars in Alkmaar was 3,051 and there were 152 attempts. In Gouda 3,256 completed and 1,326 attempted thefts from cars were recorded.
- <sup>iii</sup> In the 'others' group, schools, public buildings and offices were included.
- <sup>iv</sup> An explanation of these lower correlations can probably be found partially in the operationalisation of the number of targets. The object of residential burglary is the household. In this inquiry (like in most studies of residential burglary) the number of dwellings was counted and assumed to be more or less the same as the number of households. This assumption is not entirely correct, but it gives a small but acceptable deviation in the outcome of the analysis. In the case of theft from cars, however, this deviation is quite large. The frequency of parking lot usage differs from street to street. Along main routes, several cars can use one parking lot during the day, while in segregated residential streets one car can occupy a parking lot for several days. The number of targets for this offence is the number of cars parked in the street segment during the offence time. Since it is impossible to reliably measure this number, a practical option is to count only the number of parking lots. Whilst this is more or less the same as the number of parked cars, for the reason given above it will give an overestimation of the number of targets in general and an over-representation of the street segments with a lower frequency of parking lot usage. Another partial explanation can be found in the geographical distribution of the two offence types. Residential burglary appears to be more geographically clustered (21% of all studied street segments) than theft from cars (41% of all studied street segments).

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