Understanding passengers’ fear of crime at train stations through neighbourhood types: a study of the Copenhagen metropolitan area

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This paper presents a typomorphological analysis of train station neighbourhoods to examine passengers’ fear of crime at the station in relation to the surrounding urban form. The study defines station neighbourhood types in the Copenhagen Metropolitan area within the pedestrian catchment area (PCA), an 800m (1/2 mile) radius around the S-train stations. The types are defined through a typomorphological analysis based on urban parameters related to Crime Prevention Through Environmental Design (CPTED) and Placemaking. The types are compared to nine years of passenger surveys of fear of crime at these stations. The analysis establishes three dominant station neighbourhood types and demonstrates the relationship between them and passengers’ fear of crime at the stations. The research underlines the importance of the surrounding urban environment in the design and governance of train stations, and proposes a typomorphological method to identify potentials in regional planning and in upgrade of transit-oriented developments.

Keywords: Typomorphology; Train stations; Fear of crime; Neighbourhood type; Finger Plan; Copenhagen metropolitan area

Introduction

This research uses a typomorphological method as background to the analysis of public transport. This method defines station neighbourhood types that are compared with passenger surveys fear of crime at S-train stations to examine whether the experience of public transport is related to the surrounding urban form. In research into transportation planning, transit neighbourhood types define urban areas in relation to the use of public transport (Robert Cervero and Gorham 1995). However, the focus in this article is the influence of urban design on passenger experience of fear of crime in the Passenger
Catchment Area (PCA).

Since the 1970s urban studies have underlined the built environment’s influence on citizens’ quality of life and their experience of fear of crime (Doran and Burgess 2012)(J. Gehl 2010)(Ewing and Handy 2009)(Jeffery 1971)(J. Jacobs 1961). Fear of crime at train stations can cause passengers on public transport to avoid certain routes, not to travel after dark, or avoid using public transport altogether if they have an alternative (D’arbois De Jubainville and Vanier 2017)(CrimeConcern 2004). Stations are regarded as more unsafe than the rest of the urban environment (Københavns Kommune 2019)(Ceccato and Newton 2015)(CrimeConcern 2004), and even though they are criminogenic places because of their convergence (Brantingham and Brantingham 1995), the statistical risk of being a victim of crime is far below the fear of crime (CrimeConcern 2004)(Warr 2000). Therefore knowledge regarding which urban parameters influence perceptions of safety at train stations are of significant value, as public transport ensures both social and environmental sustainability in urban areas.

This research consists of case studies of stations on the S-train network in the Copenhagen metropolitan area. Approximately 80% of all S-train passengers either walk or cycle to the S-train station and thus they experience the PCA (Trafikstyrelsen 2009). Furthermore, S-train stations have no turnstiles or ticket-booths, being unmanned platforms that are part of the free urban flow. This integral layout makes the urban surroundings of stations important in understanding fear of crime.

This article presents a brief overview of literature and theory on the influence of the built environment on fear of crime, followed by an introduction to typomorphology. The typomorphological qualitative approach is supplemented by a GIS-based quantification of openness proportions in the stations’ neighbourhoods. The results section presents the neighbourhood typologies, compares the openness proportions of
the different neighbourhood types, and assesses the conditional probabilities that link types of neighbourhood to nine years of passenger surveys of fear of crime. A visualization of the types on the metropolitan map is discussed in relation to the historical background and geographical context. The conclusion sums up the findings and addresses topics for future research.

Theoretical background and framework

The method builds upon a theoretical framework of fear of crime in built environments in combination with typomorphological analyses of cities.

The built environment’s influence on fear of crime

The influence of the built environment on fear of crime has been thoroughly examined since the 1970s through criticisms of modernist urban planning. This took off in the 1960s with Jane Jacobs’ criticism of modernist renewal projects in residential areas of New York (J. Jacobs 1961). Jacobs was followed by scholars of architecture (Newman 1972)(J. Gehl 1971), criminology (Jeffery 1971) and psychology (I. Gehl 1971), whose research focused on how urban space and design affect residents’ mental states in relation to fear, stress, social exclusion, crime and happiness, as well as their use of public space. Since then, an increasing number of urban studies have extended this field of knowledge, refined by computer-generated isovists, GPS tracking of movements, crowd-sourcing using smart phones, and recently direct measurements of people’s responses to urban environments by using sensor-wristbands to monitor heart rates and skin conductance (Knöll et al. 2018)(König and Schneider 2014).

The spatial analysis of station neighbourhood types is rooted in Crime Prevention Through Environmental Design (CPTED)(Newman 1972)(Jeffery 1971) and targets ‘fear of crime’ (Ceccato 2015)(Doran and Burgess 2012)(Ryan et al. 2010). The
analysis also draws on theories of urban form, some of which are related to guidelines for walkability, a measure of how friendly an area is to walk in (Ewing et al. 2016), which has emerged from theories of place-making (J. Gehl 2010)(Appleyard 1981)(Whyte 1980)(www.pps.org). These guidelines form part of Transit Oriented Development (TOD) (R. Cervero, Ferrel, and Murphy 2002) (Ewing 1996), the success of which is dependent on the appropriate urban form of street networks and building patterns (Stojanovski 2018)(Vernez-Moudon 1994).

The following five characteristics are suggested in presenting an overview of parameters in the built environment that influence fear of crime in urban environments:

1. Natural surveillance, activity support and mixed use
2. Visual guidelines of territoriality and use
3. Spatial qualities; human scale, enclosure, beauty, design, robustness, visibility
4. Maintenance
5. Light

1. Natural surveillance, activity support and mixed use

Natural surveillance, or ‘eyes upon the street’ (Jacobs, 1961), refers to how public space is over-looked by members of the public as a by-product of public life. In this research natural surveillance means activities in the street by both residents and non-residents (Newman 1972). This relates to activity support, legitimate activities in support of perceptions of safety, the ability to see each other through windows and balconies, inter-visibility between buildings, entrances opening on to the street, and activities during the day that result from mixed land use (Desyllas, Connoly, and Hebbert 2003) (Felson, Clarke, and Webb 1998). Natural surveillance supports normative behaviour, which has a strong effect on perceptions of crime and safety (Desyllas, Connoly, and Hebbert 2003) (Jeffery 1971).
2. Visual guidelines of territoriality and use

Visual guidelines emphasize territoriality and use. Zones guide people in how to move and behave and encourage them to assume ownership and control on the assumption that they respect and protect the places they feel are theirs. This supports the understanding of place, as well as of the fear of crime (Action SAFEPOLIS 2007) (Newman 1972) (Jacobs 1961).

3. Spatial qualities

Spatial quality is a complex phenomenon. In this study it is defined by the notions of enclosure, refuge, human scale and complexity (beauty and robustness).

Enclosure is primary in defining space, as it creates a visual overview and coherence related to safety and comfort. The sense of enclosure is eroded if the streetscape is discontinuous, with vacant lots, parking lots, lawns or buildings set back from the road or path (Cullen 1961). A comfortable enclosure ratio ceases somewhere around 1:4, and beyond 1:6 the feeling of enclosure disappears (Harvey et al. 2015) (Spooner 1995).

Jay Appleton’s Prospect-Refuge Theory combines enduring aesthetics with a basic primal need for prospect and refuge, that is, the need to feel protected and safe, to be able to see what is coming (the predator), and also to be able to escape from it (Blobaum 2005) (Nasar and Jones 1997) (Fisher and Nasar 1992) (Appleton 1975). This makes streetscapes with tunnels, parking basements and long closed façades undesirable. This is related to ‘lurk lines’, places close to the individual that are just outside the field of vision, yet near enough to create a feeling of danger regarding what might be lurking there (Warr 1990)(Goffman 1972).

Human-scale architecture corresponds to the size of the body and is therefore possible to seize and feel connected to. Empty or out of scale areas can be perceived as

Complexity, beauty and robustness refer to visual and sensory qualities and are connected to territoriality and ownership. A complex and beautiful environment is visually stimulating and divides walking into manageable stages (Ewing and Handy 2009). Conversely, monotonous building façades can be experienced as long, dull, unstimulating and discouraging for urban life (A. B. Jacobs 1993) (J. Gehl 1971).

Neither light nor maintenance is necessarily linked to any particular urban pattern. As both parameters require detailed qualitative investigations of urban areas they are not included in investigations of fear of crime in current research.

Enclosure and natural surveillance are used as background to the measurements of openness proportions in the different types of station neighbourhood.

Typomorphological analysis of neighbourhood types

Typomorphology is the study of urban form derived from research into typical spaces and structures (Moudon 1994). It involves grouping urban patterns into typologies and classifying them. Typologies are constituted by types and classifications of urban elements, and the scale can be multiple, including windows, façades, building footprints, plot outlines, villages, cities and metropolitan areas (Moudon 1994).

Morphology is the study of patterns and the collective form of things. The scale can range from buildings to cities and territories, but in its narrowest sense morphology refers to the study of the urban fabric of buildings, plots and street patterns (Kropf 2014) (Çalişkan and Marshall 2011). Both typology and morphology have the street network, the plot and the building as the defining element (p. 42 Kropf, 2014) (p. 147 Vernez-Moudon, 1994). Moreover, they agree on the importance of the historical
process, as the type of built landscape is morphogenetic and is defined by the time of its conception, use or mutation (Oliveira 2019) (Moudon 1994). Typomorphological analyses of urban form are important for planning practice and design, as they provide a deeper understanding of an urban space (a space to which people feel no personal attachment) and can support its character so it can transform itself into a place (with personal attachment) (Olsson and Haas 2013).

A large body of research is concerned with the relationship between urban form and travel patterns (Stead and Marshall 2001) (Ewing 1996). Many of these define neighbourhood types: ‘Neighbourhood type is effectively a composite variable that is used to characterize areas of cities that are relatively homogeneous according to a range of attributes. These attributes typically include the age of development (such as post-war), the style of development (traditional, conventional or neo-traditional, for example) and the street network type (such as grid or loop or cul-de-sac)’ (Stead, 2001).

Many American definitions of ‘transit neighbourhood types’ are variations of dense urban pre-war or suburban post-war structures (Robert Cervero and Gorham 1995) (Friedman, Gordon, and Peers 1994)(Ewing 1996) (Southworth and Owens 1993). Some of the attributes characterizing the different typologies suit the Copenhagen Metropolitan area, although the examples and terminology are American. ‘Transit neighbourhoods’ are central pre-war urban areas of mixed use, reduced street hierarchies, connected streets, on-street parking, high population densities and transit services. ‘Auto neighbourhoods’ have segregated use, hierarchical street networks, partially connected streets, low residential densities, random street patterns and fewer transit services. In international typo-morphological research there are strong similarities between urban typologies, although all cities have diversities in their typologies due to culture, history, climate, use and economic factors.
Methods

The case study

The research for this article is based on case studies of S-train stations in the Copenhagen metropolitan area. The S-train network is the urban rail system in the ‘Finger Plan’ of 1947, a regional infrastructural plan for the post-war development of Copenhagen (Egnsplankontoret 1947) that largely guided the development of the region from 1947 onwards (Figure 1). The S-train system runs along the five ‘fingers’ based on existing train lines and main roads.

Most of the S-train stations were built between 1953 and 1974 as part of post-war expansion. The system has seven lines and 84 stations, covers the entire metropolitan area, and involves a diversity of urban planning and socioeconomic structures.

The analysis targets the urban layout of the pedestrian catchment area (PCA), an 800-metre (1/2 mile) radius around the S-train station platform.

Figure 1. ’The finger plan’ (Egnsplankontoret 1947).
The method for creating typomorphological maps

The analysis of station neighbourhood types is typomorphological, as it describes urban form (morphology) based on the classification of buildings and open spaces by type (typology). The maps show the building footprints (figure-ground maps) that illustrate the relationship between built and open space. They are used in urban morphology studies to visualize the mass-to-void relationship and the fabric of urban patterns (Rowe, E. Koetter 1979). When looking at station neighbourhood types with streets and building plots on cadastral maps, it looks as if a clear demarcation is present in the urban space. However, the borders and plots in modernist-inspired areas are mostly permeable, and it is often not possible to register them on site. In reality what one experiences is a vast open space, as on a figure-ground map, not a defined space like a cadastral map.

The station neighbourhood types are defined on the basis of their spatial qualities in relation to public space, the street network, the plot, the building, its use and its time of construction. First, groups of patterns are identified based on the size of the building’s footprint, the building’s use and the time of its conception. Then the distances between the buildings and their orientations towards the street and the street network are identified. The spatial relationships and urban qualities of the different building types are defined. Monuments and public buildings belong to the typology in relation to which they were built and planned (year and building style).

The 84 station neighbourhood types are GIS-mapped to show their geographical distribution in the metropolitan area (Figure 10).

The passenger survey: fear of crime at S-train stations

The typo-morphological studies are compared with passenger surveys to determine whether the layout of the transit area can be related to the experience and fear of crime.
at the station. The passenger survey of fear of crime at S-train stations contains 125,449 responses from nine years of surveys. The data stem from DSB (the Danish State Railways) from 2009-2014, followed by Passenger Pulse (the public transport passenger survey) from 2015-2018 (Forbrugerrådet Tænk 2019). The survey was handed over to a public passenger organ in 2015 to ensure public access to the data. It runs throughout the year based on approximately eight thousand questionnaires handed out yearly to a representative customer segment on S-train platforms between 6 am and 10 pm. The question about fear of crime at the station reads: ‘At the station: how satisfied are you with…..safety at the station?’ Passengers rate their perception of safety (or fear of crime) on a scale from 0 to 10, 0 being unsafe and 10 being safe. The station in question is the one they depart from (Forbrugerrådet Tænk 2019).

The openness proportions of the three neighbourhood types

Urban density is normally measured by means of a floor area ratio (FAR), but the experience of urban space and urban density in S-train station neighbourhoods is not as closely related to FAR as to the experience of a continuous streetscape and enclosure. The openness proportions make the experience of the street-scape disintegrate and are related to low urban densities and the lack of social control, i.e. eyes in the street. Neighbourhoods outside central Copenhagen with a high FAR are often modernist-inspired building structures with open greens or open parking spaces. People living in the buildings do not linger in urban spaces, as they have few activities to watch or participate in. Here, therefore, urban density is measured by the amount of open space in relation to the building footprint.

By using a GIS-based calculation of open space within circles of 25 metres width around the station platform (principle drawing in Figure 2) the percentage of open space within each circle is calculated (see Appendix for Python code). Each ring is a
point on the graph. From 25 to 300 metres there is a point for every 25 metres, with thereafter only one point per 100 metres because the law of large numbers makes the graphs flatten out. Each graph has nine or ten examples of stations that are typical neighbourhood types without parts of other typologies.

![Figure 2. Principal drawing method.](image)

**Results**

**Definition of neighbourhood types**

As the focus of this study is the station, the urban area surrounding the station entrance identifies the neighbourhood type. If the predominant part of the station neighbourhood belongs to the same typology, it becomes a main category. The three main neighbourhood types identified are: A, Dense Urban Area; B, Coherent Suburb; and C, Fragmented Suburb (Figure 3).
These neighbourhood types have subcategories if the urban fabric carries the main patterns A, B or C, but contains significant elements of one of the other patterns. For example, if the area surrounding the station is A and the minor element is C, a small letter ‘c’ is used to denote thus: Ac (Figure 4). There need to be a substantial number of building elements from another type or they need to be central to the station entrance in order to influence the urban area and denote the type.

A second variation in neighbourhood types is marked by the addition of two small letters after the main category. Thus, if the main type is Coherent Suburb B, but it is influenced by a low urban density structure (C) and secondary fragments of a village structure (A), it becomes Bca (Figure 4).
Figure 4. Sydhavn station, neighbourhood type Ac (left) and Tåstrup station, neighbourhood type Bca

_A: Dense Urban area_

Figure 5. Top: examples of Dense Urban Area. Type A. Bottom: examples of neighbourhood type A. Left: Figure-ground map of Cph K, 17th centuries. Centre: façade drawing of Laksegade 20 a, b. Bremerholm. Cph K. 1798. Topographic
A, the Dense Urban Area type (Figure 5), is located in central Copenhagen and consists of five-storey blocks of buildings with closed internal courtyards. The city centre dates from the seventeenth century, while the urban areas to the south, east and north-east of the centre were built for the working classes in the nineteenth and twentieth centuries.

This neighbourhood type has a high density, and the building footprints, the road network and the open plazas testify to tight planning and organization of the urban structure. The building scale is human, and the building materials are robust, with ornaments and high visual complexity. Here there is mixed use (ground-floor shops, with apartments on the first to fifth floors), connected streets in ‘X’ intersections, on-street parking and high population densities. There is a distinct sense of enclosure: in some streets the enclosure ratio is 2:1, the street being ten metres wide and the buildings twenty metres tall. The level of natural surveillance is high: the façades have many windows and balconies, and the ground-floor shops are glass-fronted. There is activity and people on the street during the day, and in some areas also at night.

The large voids in the figure-ground plans represent the harbour, lakes and park areas, with their remains of seventeenth-century fortifications. These areas are demarcated with fences, greenery or stemmed trees towards the sidewalk. Some of the large voids alongside the tracks are railroad yards, for example, Svanemøllen, Bispebjerg and Dybølsbro stations (Appendix, Figure 1). The railroad yard creates a void next to or around the platform, and despite the dense urban area, passengers may experience the station as having low natural surveillance.

The S-train stations in typomorphology A are either in an open trench or above ground, or else they run along an embankment. One station, Nørreport, is underground.
This station is in the centre of Copenhagen and is a combined metro, S-train and regional train station with a high degree of activity: approximately 208,000 passengers a day (buses and regional trains not included) use the S-train and metro platforms.

**B: Coherent Suburb**

Station neighbourhood type B, Coherent Suburb, have a considerably lower degree of land occupation than A, the Dense Urban Area type (Figure 9). Most of the building mass consists of one- to two-storey single family housing. The building footprints are small and are spread out in a homogeneous pattern with lines and blocks juxtaposed in a consistent manner. The infrastructure is slim, the streets are well connected in ‘X’ intersections and the hierarchy of roads disappears, providing a coherent pattern to the suburb. Most of these areas close to Copenhagen were built between 1900 and 1950, some of them being the remains of old village structures like Tåstrup (Figure 4). The distances between the façades on each side of the road are between twenty and forty metres, but, as is typical of this suburban neighbourhood type in Europe, the front gardens have trees and hedges along the sidewalk which create a clear demarcation between private and public spaces. The enclosed public space is mostly ten metres or narrower, and people on each side of the road are within talking distance of one another. These areas have a variety of building designs and details. Most of the buildings were constructed using non-industrialized building processes. Here is a tradition of ornaments and of a clear demarcation of private, semi-private, semi-public and public spaces through greenery, fences, hedges, front lawns, doorsteps, balusters, etc. The scale is human, with a high level of territoriality, visual diversity and defined space. Natural surveillance varies: some have people passing through, open windows towards the road and activities on the front lawns, while others are more remote, with low levels of activity or high hedges towards the street.
In this neighbourhood type, the train tracks are mostly on an embankment above ground, and the coherent pattern of houses encloses the station, leaving little or no space to park cars or buses. In some areas the level of natural surveillance can be low close to the station, as many gardens have high fences, hedges and greenery facing the road to create privacy.


**C: Fragmented Suburb**

Type C, Fragmented Suburb (Figure 7), contains fragments of different types of urban fabric or groups of types, divided by wide infrastructural patterns or undefined land-use, which create gaps between the fragments. The different fragments may be areas of multiple-storey buildings consisting of social housing, single family housing, factories, industrial areas, large shopping centres etc. What is significant is the lack of interaction
and connectivity between them. This neighbourhood type differs from A and B in having larger areas of open space in between ‘islands’ of built environment, leading the spatial characteristics of this contemporary city to be referred to in the Danish literature as ‘leftover landscapes’ (Nielsen 2001). Here the spatial hierarchy is multiple, and the organization of elements gives the impression that they are drifting apart. This neighbourhood type stems from post-war development continuing up until the present day.

This post-war development has given rise to types inspired by the modernist ideas of the early twentieth century, when industrial work, recreation and family life were separated and systematized. Functionality and health were the most important factors in architectural planning, and open green areas were thought of as the best way to create cities. The ‘car age’ had arrived and was a central concern of planners, meaning that the scale of the infrastructure for cars set the standard for these urban areas (Nielsen 2008). This, combined with thoughts about open green spaces and segregated traffic, created cities with low building densities and low levels of social interaction.

The modernist-inspired typologies in these areas are shaped by the industrialization of the Danish building sector that took place from the 1950s. The use of concrete elements, the enthusiastic exposure of assembly techniques and the dimensions of assembly-line crane tracks informed public housing settlements, as well as the planning of entire areas. This new fast building technique accommodated a growing population, urbanization, industrialization and economic growth (Nielsen 2008) (Realdania 2010) in most western countries.

Station neighbourhood type C is characterized by low urban density and low walkability; the roads are broad, and there is plenty of parking around the station. There is low urban activity with no active façades, a low sense of enclosure and few active ground floors.

The railroad tracks and platforms are on an embankment, within which the staircase and elevator to the platform are often located, accessible from a tunnel entrance. There are trees and greenery on the banks and around the entrance, as well as parking for bicycles. This layout can cause low visibility, and the tunnel entrance can promote a feeling of low possibilities of escape (Figure 8). The original plan was to have a ticket vendor and shops or a kiosk at the station, but the ticketing became automated and later digital, the offices are now closed, and the premises are vacant. Some stations have a kiosk at the tunnel entrance.
Several type C areas have a large mall just next to the station, but the buildings present a closed or windowless façade to the station entrance, and most buildings close to the stations do not use the full potential of activity from a transport node. This is unfortunate when it comes to natural surveillance and fear of crime (Figure 8, right).

Figure 8. Left: Tunnel entrance from Avedøre station. 2017. Centre: Inside the tunnel entrance, 2017. Right: Karlslunde station with a shopping facility presenting a blind façade tow the station entrance, 2017.

**Openness proportions and neighbourhood types**

The three graphs show the openness proportions of each of the station neighbourhood types. A, Dense Urban Area, have the densest footprints, an average of 70.8% open space and also divergent curves, mostly because of the parks and lakes in central Copenhagen. The grey line with high density within the first 90 metres represents Copenhagen Central Station, which has a large station building and a roof construction covering the tracks. B, Coherent Suburb, have higher openness proportions of 83.7% and very even patterns, with almost the same level of openness for all station neighbourhoods within 800 metres. The patterns in type C are more even than in A, with an average openness proportion of 83.1%. The yellow line with high density within the first 65 metres is Ballerup station, which has a mall at the station.

According to urban design guidelines for transit-oriented development (TOD)(Calthorpe 1993), in promoting sustainable urban planning around train stations,
densifying the urban area around the station is important to enable human activity (natural surveillance). The graphs reveal that urban space do not densify around the S-train stations in terms of building footprints.

Figure 9. Above: neighbourhood type A. Centre: neighbourhood type C. Below: neighbourhood type B.

The neighbourhood types on a map

The historical background and explanations for the location of the urban patterns are illustrated in Figure 10, a GIS mapping of neighbourhood types. The map shows that
Dense Urban Areas are concentrated in the centre of Copenhagen. B, Coherent Suburb, is a suburban zone of single family houses extending to the north. The northern municipalities became well established early because of the attractive landscape, which housed the summer residents of wealthy families and the nobility. The western and southern parts of Greater Copenhagen had large areas of undeveloped land, leading to a larger distribution of both public housing and industry. This meant that the modernist influence on planning was stronger in these areas (Nielsen 2008)(Realdania 2010).

Historically Copenhagen expanded to the north of the city because of the attractive landscape, which housed the summer residents of wealthy families and the nobility. The larger part of the area was built before 1950 and falls into the Coherent Suburb neighbourhood type.

C, Fragmented Suburban Area, is the peripheral neighbourhood type that spreads to the north-west, west and south of Copenhagen. This area represents the post-war expansion of Copenhagen, which involved a great deal of public housing and industrial planning. The Finger Plan sought to establish an even distribution of residents around Copenhagen by planning the western area and the southern coastline (Egnsplankontoret 1947).
Figure 10. The three neighbourhood types on a map of Copenhagen.

*Comparing neighbourhood types with passengers’ fear of crime*

As already mentioned, the passenger surveys from Passenger Pulse and the DSB provide data on mean perceptions of safety at each station, based on interviews with 125,449 passengers. An estimate of a probability distribution (a kernel density estimate or KDE) is made for each of the neighbourhood types A, B and C. Only a single mean value for each of the 84 S-train stations exists, as the data come in aggregated form. As a result, there are too few samples in each sub-category to produce a precise distribution
of them. However, it is possible to produce an average weight and a standard deviation for each type of station neighbourhood (Figure 11).

Figure 11. Left. Density plot: the likelihood (probability density) of the three different neighbourhood types being perceived as safe. Neighbourhood type A is the red curve, B is in green, and C is in yellow. Right: main types A, B and C and subcategories, average mean and standard deviations.

The three curves show the likelihood of each neighbourhood type being perceived as safe. The normative value goes from unsafe 0 to safe 10, where the average for each station goes from 6.3 to 9.4. Looking at the red curve, A, Dense Urban neighbourhood, shows a wide distribution ranging from stations perceived as comparatively less safe and more safe. The deviations are due to special circumstances around three type A stations perceived as unsafe: Nørreport, Sydhavnen and Nørrebro, because of they are crowded and have signs of low maintenance and a low socioeconomic environment (see Appendix for elaboration). They differ from other type A stations, which are perceived as safe.

The green curve, B, Coherent Suburb neighbourhood, has a leftward skew, though the majority of probability mass show that stations in this typology have a high
probability of being perceived as safe. Type B stations also have the highest mean safety score (7.71).

The yellow curve, C, Fragmented Suburb, has an average value of 7.35, being the lowest of the three main types. Type C also contains the station with the lowest mean safety score.

The means, Avr, in Figure 11, right, show that type A (Dense Urban Area) and B (Coherent Suburb) are the safest and type C (Fragmented Suburb) the least safe. The mean and standard deviations (Std) of the subcategories are consistent with the main categories: subcategories of B are less safe than pure B, subcategory A+b is safer, and subcategory A+c is less safe. Subcategory C+a,b or ba is safer than pure C. Only one sub-category, C+ab, deviates from the categories.

Further investigation is needed into how these values and distributions change over time. Access to disaggregated data and similar data from previous years may indicate a direct relationship between neighbourhood types and fear of crime.

Discussion

The question posed in the passenger survey: ‘How satisfied are you with safety at the station?’, can be misunderstood, since ‘safety’ can mean practical safety. However, the large scale of the survey (125,449 passengers) makes it possible to draw conclusions on fear of crime.

Other parameters may influence passengers’ fear of crime, such as local station design, hear-say about an area, poor lighting, maintenance or the opening hours of a bar serving alcohol close to the station. Therefore, the analysis of passengers’ fear of crime in relation to urban typologies must be interpreted with caution.
The figure-ground plan analysis provides an overview of the urban fabric but only covers the built environment, not greenery, trees and their canopies, which can provide enclosure, scale and aesthetic quality. The foliage disappears in winter, but the trees still create a sense of space. The urban typologies of a built-up area are regarded as providing a framework for future detailed analyses of S-station neighbourhoods in the Copenhagen metropolitan area.

Central to the discussion of fear of crime in public spaces is the influence of socioeconomic structure, as this is related to low perceptions of safety in public spaces (Pantazis 2000) (Taylor and Hale 1986). Future research will include a correlation between perceived safety at stations, neighbourhood types and income levels in station neighbourhoods.

Conclusion

This study has defined three neighbourhood types in the Copenhagen metropolitan area on the basis of parameters related to the experience of urban space: Dense Urban Area, Coherent Suburb and Fragmented Suburb.

In post-war planning the Fragmented Suburb type is perceived as the most unsafe, which confirms existing research on the experience of modernist inspired areas. This type has low levels of natural surveillance, large-scale building structures, and urban space dominated by car infrastructure. The physical characteristics related to this neighbourhood type do not accommodate social activities in the streets: urban density in this regard is low, the streetscape disintegrates as building façades are drawn back from the street, and there are few activities for citizens in the public space.

Dense Urban Area-type S-train stations are perceived to be safer, with the exception of a few stations. The Dense Urban Area station neighbourhood type has a high level of natural surveillance because of the urban activity in the streets, shop
windows on the ground floor, and windows from apartments facing the streets. Especially in the summer, many cafes spill on to the streets. The streetscape has a high level of enclosure and visual diversity. The tables from the analysis of openness proportions in the three types support the typomorphological analysis of urban space.

The Coherent Suburb type dates from before 1950 and consists mostly of single family housing with clear demarcations between public and private zones and a defined streetscape with visual diversity. The streets are narrow, and the windows face the street, although often set back by a front yard. These areas are seen as safe despite the low level of urban activity.

The relationship between station neighbourhood type and passengers’ fear of crime at S-train stations strongly indicate that passenger experience of public transport is related to the station’s neighbourhood type. This suggests that the focus on fear of crime preventing measures in station design is more important in some urban areas than in others. As a preliminary analysis of station catchment areas, the GIS analysis of openness proportions is operational and can visualize the structures of urban densification in passenger catchment areas. The typomorphological method is suitable for a preliminary analysis of urban transformations of public transport-oriented developments. Furthermore, the deeper understanding of the characteristics of a place allows its potentials to be explored and used in an urban regeneration. In the present case the analysis can be used to support Danish State Railways create an overview of their business and of the challenges and qualities imbedded in the geography of place.

References


Ewing, Reid, Susan Handy, Ross C. Brownson, Otto Clemente, and Emily Winston. 2016. ‘Identifying and Measuring Urban Design Qualities Related to Walkability’. *Journal of


Ryan, Sean, Bill Pitard, Vice Chair, Pb Americas, Randy Clarke, John Plante, April Panzer, et al. 2010. ‘Crime Prevention Through Environmental Design (CPTED) for Transit Facilities’.


