Patterns and predictability of visual attention in different street types

An eye tracking study exploring the predictability of the distribution of human visual attention based on the spatial arrangements of buildings in a two-dimensional plan.

Martin Månsson
Blekinge Institute of Technology
Master’s Thesis in Spatial Planning
January-June 2017

Supervised by:
Abdellah Abarkan

Examined by:
Bertil Malmström
Abstract

Streets are the most resilient elements in a city. While buildings are replaced and property borders redrawn, the streets remain. The primary means of planning new streets and the built environment surrounding it is by the creation of a two-dimensional plan - in a Swedish context called a detailed development plan. The two-dimensional plan is sometimes criticized for its inability to take the three-dimensional world into account and thus its inability to predict the actual outcome of the plan. To address this critique and provide additional understanding for this planning device, this paper empirically explores if the distribution of visual attention can be predicted from a two-dimensional plan. Visual attention is explored due to sight being the most prominent means used by humans to gather information in the urban environment. Fifteen subjects performed a simple, computerized eye-tracking experiment, whereby their visual attention was measured as they looked at 40 images on a monitor. The 40 images depicts four different street types: blocked, open, curved and angled, each of which was represented with a simple figure image, as per interpretation from a two-dimensional plan, as well as a photograph of the same environment, representing the actual outcome of the plan. The results show that the simple figure images have effective predictive capabilities, as the distribution of visual attention exhibited a similar pattern in both the figure image and the photograph. The results also show that different patterns of visual attention are evoked by each of the four different street types. In sum, the results indicate that two-dimensional plans are able to predict the future three-dimensional outcome of a given plan in terms of visual attention. These indications are valuable for planners, architects, engineers and decision-makers when planning for new urban environments. The results are also valuable for understanding human perception of streets in a wider context.
Abstract

Acknowledgements

1. Introduction

2. Background
   2.1. Two-dimensional planning 9
   2.2. What’s a street? 10
   2.3. Street types
      2.3.1. Historical perspective 12
      2.3.2. Figure-ground theory 15
   2.4. Streetscape features and elements 18
      2.4.1. Fixed features 19
      2.4.2. Semi-fixed features and Non-fixed features 22
   2.5. Perceiving the streetscape 22
      2.5.1. Mass relations 24
      Coherence 24
      2.5.2. Fixed features 26
      2.5.3. Semi-fixed features and Non-fixed features 27
      Signage 27
      Greenery 28
      People 28
   2.6. Eye tracking research 29
      2.6.1. Visual attention 29
      2.6.2. Previous research 31
   2.7. Analysis tools 33

3. Method
   3.1. Experiment 34
   3.2. Stimuli
      3.2.1. Blocked street type 38
      2.3.2. Open street type 39
      2.3.3. Curved street type 40
      2.3.4. Angled street type 41
   3.3. Stimuli representation 42
   3.4. Eye tracking experiment 43
      3.4.1. Design 43
      3.4.2. Participants 43
      3.4.3. Apparatus & software 44
      3.4.4. Procedure 45
      3.4.5. Tasks 46
4. Results
  4.1. Blocked street type
  4.2. Open street type
  4.3. Curved street type
  4.4. Angled street type

5. Discussion
  5.1. Blocked street type
  5.2. Open street type
  5.3. Curved street type
  5.4. Angled street type

6. Conclusion
  6.1. Is it possible to predict human visual attention in an urban environment based on the spatial arrangement reflected in a two-dimensional plan?
  6.2. How can this predictive ability help planners and decision makers?

7. Further research and other indications

8. References

Appendices
  Appendix 1. Slideshow order
  Appendix 2. Form of consent
“The design of streets as a coherent whole is a skill that has atrophied through the twentieth century and is only now being rediscovered.”

Matthew Carmona et. al. (2010, 184)
Acknowledgements

I would like to thank my supervisor Abdellah Abarkan for providing excellent material and critical input on this thesis. I would also like to thank Dr. Adrian Voßkühler for providing free eye tracking compatible software, without which this experiment could not have been conducted. A thank you to the staffers in Jönköping Public Library for letting me conduct my experiment in their locales. I’m also grateful for Google’s generous terms of use that allowed me to gather relevant stimuli for the experiment.

And finally, thanks to my family and friends for supporting me.
1. Introduction

Swedish urban planning is primarily controlled using the municipal detailed development plan. This plan regulates the use of land areas as well as how the built environment is to look like in a particular area. A plan is a two-dimensional image which defines the use and design of public spaces (Boverket 2017). Public spaces such as streets are features in the city that, once constructed, as per the detailed development plan, are one of the most time-resilient features in a city. While buildings are replaced and plots redrawn, the layout of streets tend to persist (Conzen 2005, 61; Whitehand 2001, 107; Larkham 1995; Oliveira 2016, 15). Given that a two-dimensional detailed development plan is the primary means of creating the layout for streets, it is important that the layouts’ three-dimensional effects are understood. Streets comes in different shapes and sizes, and given what gestalt theory informs us about how the eye movement reacts differently to different arrangements of solids and voids, it is arguably appropriate to investigate the visual effects of different arrangement of buildings and streets, especially since most of the information in the urban environment is gathered through our vision (Carmona 2003, 111; Whyte 1980, 58; Folkesson 2015, 13).

Research has been conducted to better understand the function of the street and its influence on people's’ behavior and perception. Bailenson et al. (2000) suggest that people rely on heuristics when choose which path to go through when going from point A to point B. A heuristic method is a method sufficient for achieving an immediate goal, without necessarily being optimal. The result of using this method is that people tend to prefer to follow straight streets. Individual street scenes have also been measured using eye tracking devices in order to see what captures the visual attention of humans perceiving a given scene. Visual attention is a term used to describe a given point or an area in the environment that attracts the eyes. One study found that a recurring phenomenon that attracted the perceiver's visual attention on straight commercial streets were the street’s vanishing point as well as commercial signs (Chang & Ching-Horng 2015).

As the layout of a given street is a particularly persistent element in the urban environment that has been shown to influence human behavior, it is arguably important that we gain a better understanding of the effects that different street types have. Knowledge about how these immediate effects could be predicted as early as during the creation of a two-dimensional development plan should be of utmost importance for urban planners, engineers and decision-makers. To this end, this thesis explores the predictability of visual attention from planning to outcome in different street types.
The purpose of this thesis is to investigate how the use of a two-dimensional detailed development plan can help to predict the patterns of visual attention in the urban street environment once a plan is fully realized. A realized plan being a built-up three-dimensional environment. By investigating the predictive abilities of the detailed development plan it is possible to introduce new tools for planners and decision-makers in their pursuit of creating a built environment that corresponds to a desired goal. The two questions posed in this thesis are:

- Is it possible to predict human visual attention in an urban environment based on the spatial arrangement reflected in a two-dimensional plan?
- How can this predictive ability help planners and decision-makers?

Before addressing these questions, a comprehensive background information is provided in the following order. First, a brief overview of two-dimensional planning is given. Second, the thesis frame what a street is and how to quantify it in order to analyze the results of the eye tracking experiment. Third, research on the perception of street environments is provided in order to discuss the finding of the eye tracking experiment. Finally, previous research conducted with eye tracking devices is presented.
2. Background

This chapter establishes the context in which the thesis will ask its two questions. It also provides tools for how to quantify and analyze the results.

2.1. Two-dimensional planning

The two-dimensional plan (such as master plans and development plans) is the spatial representation which planners traditionally use in order to offer objective representations of urban spaces. This is a central concept for the planning practice throughout the world and is an approach deeply embedded in the mind of planners. Such representations are however trapped within the confines of two-dimensional representations (Healey 1999, 629).

Trancik (1986, 1) argues that the problem of urban design today stems from the process of urban development treating buildings as isolated objects situated in the landscape, not as part of the larger fabric of streets, squares and viable open space. Decisions about growth patterns are made from two-dimensional land-use plan, without considering the three-dimensional relationships between buildings and spaces and without real understanding of human behavior. Trancik claims that this process usually leads to the planning of buildings or sites that do not effectively relate to their surroundings.

Much like Trancik, Shao (2015, 151) also observes the disconnect between the two-dimensional plan and the three-dimensional reality. Shao refers to the common practice of providing a miniature two-dimensional plan whose perspective is that from a helicopter. But this is not the perspective of the people, for they see a three-dimensional space and its three-dimensional effects. It is clear that this way of planning has produced a demand to better understand the effects these two-dimensional plans has on the people in the three-dimensional space.

What the above authors suggests here is that a small two-dimensional urban plan fails to take into account the complexity of the real three-dimensional world. One step towards investigating whether this understanding is justified, could be to find whether it is at all possible to predict, from a two-dimensional plan to the realized three-dimensional product, how people’s visual attention is going to be affected.

The Swedish detailed development plan closely resembles a figure-ground plan (see chapter 2.3.2.). It’s a two-dimensional plan, which is subject to the above authors’ critique. The yellow and brown areas represents plots for buildings, while the white areas represents streets. This particular detailed development plan would fit the classification of a blocked street type as the street is terminated with a building facade (see chapter 3.2.). The detailed development plan, apart from deciding the footprints of streets and buildings, usually also sets a maximum height for buildings, and in some instances even the angle of the roof, thus laying the foundation for the future three-dimensional space (Boverket 2014, 141, 154, 195, 230).
These three guidelines, building footprint, building height and roof angle, will be used throughout the thesis as it helps us to represent the two-dimensional plan in a three-dimensional image (more on this on chapter 3.2) in order to investigate the predictability of visual attention in early planning stages.

2.2. What’s a street?

[In] urban design the main actors in the play [...] are the square, the street and the buildings that make up the public face of towns and cities.

Sebastiano Serlio (1475-1554)

Routes, highways, roads, paths and streets are among many words that are used to describe a physical manifestation running along the landscape on which movements occurs in order to travel from one point to another. But as we read the above five descriptive words we probably visualize five completely different ways in which they actually manifest in the physical world; what do you expect to move along when you hear “take that road” or “take that street”?

In this thesis the street is the word of choice, but why is that? Cliff Moughtin (2003, 129) talks primarily about the difference between the road and the street. The purpose of both a road and a street is to get from point A to point B. Moughtin however states that the difference lies in that streets are incompatible with roads when it comes to the road’s fast and heavy traffic with all its engineering requirements - meaning that the road’s main attribute should be to handle heavy, fast and high amount of traffic. Similar to Moughtin, Carmona (2014, 182) also finds purpose in distinguishing between roads and streets. He concludes that that
the primary purpose of the former is being a thoroughfare for vehicular traffic, while streets are multi-functional in the sense that it also provide space for delivering, cycling, parking, sitting, etc.

The Manual for Streets (2007, 12), a design manual published for the Department of Transport in United Kingdom, concurs with the multi-functionality proposed by Carmona (2014, 182) by defining streets as highways that has important public realm functions beyond the movement of traffic. The definition goes on by stating that a street should provide direct access to the spaces and buildings that line the street.

Marshall (2005, 6) illustrates the street composition by describing that a street is not a street in its true sense unless it is an intimate mix of a circulation route, a public space and a built frontage (See Figure 2).

Furthermore, Carmona (2014, 179-183) elaborates on the distinction between the street and the plaza. ‘Plaza’ usually refers to an area framed by buildings, or walls. Unlike the plaza, the street is mainly enclosed by two walls that defines its space. To further help with separating the street from the plaza, Carmona puts forward three width-to-length ratios: 2:3, 1:3 and 1:5 (See Figure 3).

If the width-to-length ratio is 2:3 no axis dominates the space and can thus be considered a plaza. When the ratio closes to 1:3 there is a form of transformation between the plaza and the street due to one axis starting to dominate. At 1:5 there is a clear domination of one axis and the space suggests a movement along this axis - proportions more than this suggests a street.

Figure 2. Showing that streets are the results of public space, movement channels and built form coming together. Illustration adapted from Stephen Marshall (2005).

Figure 3. Illustration adapted from Carmona (2014)
It could be concluded that the street is not simply a thoroughfare, unlike a road, and it’s a framed space with a dominating axis, unlike a plaza. To avoid pinpointing how many alternatives could possibly fit in the definition provided above, this thesis will sum up the definition of a street by quoting Marshall (2005, 22):

“A street can be seen as a road that happens to have an urban character; or as an urban place, that happens to serve as a right of way.”

Thus, for the purposes of this study, streets are the more or less narrow, linear spaces lined by buildings, fences, walls, and the like, found in urban settings and used for circulation and other activities (Rapoport 1989). In this thesis exact ratios will not be given, but a street will be identified by simply being an urban space with a very dominant axis.

2.3. Street types

Throughout time, architectural theorists have favored certain types of streets over others. In the late 1st century B.C., Vitruvius finished his *De Architectura*, where he describes how a city should have straight radiating streets as to combat unhealthy winds (1914, 30). In the 15th century, Leon Battista Alberti softened this position by proposing that differently sized cities have different ideal street types. He writes in his *De Re Aedificatoria* that streets in big cities should be straight and broad to allow for majestic winds - but if the town is small, it should have curved and winding streets to ensure that a new facade experience comes with every step (1774, 248). In the 19th century, Camillo Sitte softened this position even further by advocating for the use of both straight and curved streets and that both street types have their place in a city depending on the purpose of each street (2006, 205). In the 20th century, Le Corbusier (1929) took us back to the ideal of Vitruvius by stating that "the winding road is the pack-donkey’s way, the straight road is man’s way". But it seems that regardless of how the street looks like, be it straight or curved, one is sure to find examples of functional streets of many types. Perhaps this preference of certain street types can be summed up by how the philosopher Alain de Botton (2008, 96) puts it:

“For proof of the capriciousness with which architectural [...] styles fall victim to baleful associations we need only note that, in most cases, little besides time is required for them to recover their charm”.

With this being said, this chapter will not focus on what a successful street type might be, but rather to explore what a given street type is. The street types found in this chapter will then be used as stimuli in the empirical part of this thesis.

2.3.1. Historical perspective

The design and non-design of streets differs between periods in time. Straight streets in a grid like manner can be traced to the cities of the early river valley civilizations of the world, such as Giza on the Nile, Mohenjo Daro on the Indus and Borsippa on the Euphrates (Kostof 2014, 194). Hippodamus provides early evidence of a designed city plan, namely the famous grid street example of Miletus 400 B.C.E. Many mainland greek cities maintained a rather
organic street type pattern, but the Greek colonies, such as Miletus, throughout the Mediterranean Sea were planned as gridiron cities (Hall 1998, 16, Bacon 1976, 75). The tradition of idealising the straight street as found in the Greek grid patterns continued on in Hellenistic and Roman times (Bacon 1976, 75).

When the Roman empire declined, and history moves into the early medieval period (ca 500-1000 C.E.), Europe produced many of its organic cities, whose design are perceived as less of an effort to achieve an ideal, and more of an unplanned extension and growth of towns (Kostof 2014, 108).

In the high medieval period (ca 1000-1300 C.E.), however, the gridiron layout became realized yet again when waves of new towns were, by the order of kings, actively founded and designed in western, central and southern Europe due to a population boom that affected most of the continent (Kostof 2014, 108). These new towns drew their influence from remnants of Roman cities, such as Cologne in Germany.

During both the early and high medieval period the Scandinavian towns and cities start to form, grow and gain prominence. The cities grew organically and there did not seem to be an attempt to regulate the street fabric of the cities (Åström 1967, 14), although, Åström (1993, 18) refers to Lewis Mumford as a researcher who claims that the medieval organic cities were not spontaneous, but were instead regulated due to their aesthetic values.

During the Renaissance era (1500-1700 C.E.) the straight streets of the gridiron still persists as the go-to solution for expanding cities as well as for newly founded cities. This era coincides with the expansion of the Scandinavian kingdoms, and especially Sweden (Hall 1998, 22; Åström 1967, 22). While formerly being dominated by organic cities with roots from the early middle ages, new cities were both founded and rebuilt in accordance with the continental gridiron ideal - and the streets were thus redesigned (Kostof 2014, 111; RAÄ...
The renaissance era ended with a relatively new ideal coming into practice. This new ideal still embraced the gridiron, but added on the diagonal streets in the city planner’s toolbox (Kostof 2014, 112). The diagonal street also became an element in some Swedish cities during this time (1998, 31).

The baroque era is more of an era of distinct artistic principles, more so than a period defined solely by time. Nevertheless, one can say that the artistic principles of the baroque had its roots in the 1500’s and enhanced the idea of the diagonal street as well as that of closing off the street vista with terminating buildings or monuments. The diagonally designed streets produced angles and splits in the environment rarely seen on large scale in any urban fabric before. This sort of street design came to be called the grand manner, and would persist as the ideal until at least the end of the 19th century (Kostof 2014, 216; Hall 1998, 46).

Many Swedish cities had gridiron plans with fortifications devised for them in order to cope with the new militarily advancements made in Europe, and many of these plans were also realized to certain degrees (Åström 1967, 22). Denmark did not undergo the same extensive gridiron planning that Sweden did, and kept most of its organic city cores that only a handful of Swedish cities can showcase today.

Until Camillo Sitte (2006) wrote his famous work promoting the organic street pattern in the late 19th century, Kostof (2014, 69) argues that the organic city form, in contrast to straight streets, have rarely been appreciated as a rational choice until modern times. Alberti, as mentioned in the prelude to this chapter, being one of seemingly few urban theorists of his time to consider the planned organic city as preferable in at least some cases (Kostof 2014, 69).
Recounting all of these historical periods, going back and forth between ideals and principles, applied to different extents and locations, has affected how the streets take their forms and creates major street type variations between and within cities. We can primarily see that the curved street, the straight street and the diagonal street, sometimes closed off by a terminating building, are the major street types in a European and Scandinavian context. We can in a Scandinavian setting alone suspect that all of these different ideals are represented and commonplace.

2.3.2. Figure-ground theory

In the previous part of this chapter we briefly explored the historical perspective in order to identify street types that are likely present in a Scandinavian setting. This part of the chapter describes how the different street types can better be identified, as is needed since the choice of stimuli used in the experiment will depend on the classification of street types.

Trancik (1986, 98) presents the figure-ground theory, which is the study of building land coverage in the form of solid mass (figure) in relation to open voids (ground). An urban environment has a pattern of these solids and voids which together establishes the city’s spaces, streets and built forms. The figure-ground theory is commonly illustrated as a two-dimensional abstraction in plan view, where solids are black and voids are white, as shown in figure 8.

![Figure 8. Figure-ground illustration. Jönköping, Sweden. White areas are voids, representing streets, and black areas are solids, representing buildings.](image)

Trancik (1986, 101) describes the urban-solids to include forms such as public monuments, dominant institutional buildings, urban blocks and directional or edge-defining buildings. The urban voids includes entry foyers, inner-block voids, networks of streets and plazas, parks and gardens as well as linear open-space systems.

Not only is the figure-ground theory revealing the aggregate urban form or character, but these illustrations helps to identify relational differences in urban solids and voids which in turn allows one to classify them by type. Looking at the example in figure 8, it is possible to discern the differences in the solid-void relations. Traveling along each of the three colored
areas as depicted in figure 9, one will experience the solid-void relations differently. One might also be inclined to give these differences names, such as irregular, straight and curved relations. In this thesis, these relational differences in voids and solids will be equated to street types.

Figure 9. Three different solid-void relations makes three different street types. Jönköping, Sweden.

Baykan Günay (2007, 96) suggests that the so called Gestalt theory could be what allows people to make distinctions between portions of the urban form, and hence find the relations shown in figure 9. The Gestalt theory (gestalt meaning shape, form, pattern etc.) is used to distinguish recognizable and related elements in any medium build-up of any whole and its parts. The major principle in this theory is that all objects stand with reference to a background, much like the figure-ground illustration. This principle of distinguishing an object from its background is fundamental when one looks for form. In the figure-ground theory the distinction of object and background is straight-forward due to the abstraction in black and white.

Roy Behrens (1998, 301) refers to Wertheimer, one of the founders of the Gestalt theory, who formulated three essential rules to achieve the belonging and togetherness of elements. These rules were: Similarity (elements that look alike), Proximity (elements that are close together) and Continuity (elements that show good continuance). According to Baykan Günay (2007, 96), with the increased popularity of the theory in the design field, other rules were added such as Enclosure (parts enclosing a void), Symmetry (coherence of composition), Alignment (lining up elements to form groups or wholes) and Simplicity (legible parts and wholes). There are certainly more principles than this that could be added to the list, such as Common ground (elements within the same field or ground are distinguished from what lies outside) as described by Carmona (2003, 171). These are some of the rules to follow to achieve the major principle of Gestalt theory, to find and identify form.

For example, the colors in figure 9 groups in three portions of solid-void relations and are assumed to be consistent within themselves, yet separate from each other, even though they belong to the same urban whole. This is done through identification of elements, patterns and form using the above rules of Gestalt theory. This being said, Gestalt theory and figure-ground theory are well compatible. By illustrating urban form in this way, authors have identified different solid-void relations - or street types.
Trancik (1986, 101) provides six examples of such street types:

![Grid](image1) ![Angular](image2) ![Curvilinear](image3)

![Radial concentric](image4) ![Axial](image5) ![Organic](image6)

Figure 10. Different solid-void relations are classified and given names such as above. This thesis calls these relations **street types**.

The street types that could be classified using Gestalt theory and figure-ground illustrations in this way are many. Marshall has compiled a list of some street/settlement types that has been identified by other authors (Table 1). By making use of the Gestalt theory and solid-void illustrations, as well as making use of the historical perspective, this thesis identifies four street types that will be used as stimuli (see chapter 3.2.).

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>5. Radiating lines</td>
<td>5. Clustered</td>
<td>5. Other grid (parallel, triangular, hexagonal)</td>
<td>5. Unique structures</td>
<td>5. Linear city</td>
</tr>
</tbody>
</table>

Table 1. Examples of street/settlement types, as presented by Marshall (2006, 75).
2.4. Streetscape features and elements

The thesis has presented and utilised methods for identifying overarching classifications of streets and street types. These past methods will allow us to choose environments of interest for the experiment at hand. This part of the chapter will focus on the three-dimensional aspects of the street. This is done in order to clarify what elements constitutes the makeup of the streetscape. The streetscape being the overarching term encompassing the street environment in all its entirety and content. This will conclude the description of the environmental context in which the thesis will ask its questions.

Figure 11. The street is surrounded by fixed features in the form of buildings, together they form a blocked vista. To the left one can spot semi-fixed features in the form of street furnishing and signage. On said furniture are non-fixed features in the form of humans as well as a car in the very center of the picture. On the right side of the picture one can find greenery, which are also elements belonging to the semi-fixed features. All of these feature elements makes up the street environment - the streetscape.

Ny Adelgade, Copenhagen, Denmark (Google Street View)

Amos Rapoport (1990, 11) notes that the streetscape consists of fixed, semi-fixed and non-fixed feature elements (see figure 11). Fixed feature elements are the architectural artifacts of the built environment, such as buildings and their various constituents such as dormers, protrusions, cornices etc. The semi-fixed feature elements are also part of the built environment but are instead described as non-architectural artifacts, such as furnishing, signs, greenery and public art. The non-fixed feature elements are cars, bikes or humans, and even human behavior. Unlike fixed elements, such as buildings, the semi-fixed and non-fixed elements are temporal aspects of the streetscape. The non-fixed elements are not always present in the streetscape and semi-fixed elements like seating areas and signs may also not be present during evening or morning hours or whenever a store chooses to change or remove their furnishing. The domain which this thesis will delve in is concerned with all
of these feature elements as described by Rapoport, but the main focus of the thesis will be on the specific arrangement of fixed feature elements and their impact on visual attention.

2.4.1. Fixed features

We will further deconstruct the streetscape in its constituent parts by breaking down the fixed feature elements, or buildings. Consider the two following images, A and B, that both depict a curved street type as explained in the previous chapter. Both images depict the same street type and are aligned with buildings. But the surrounding buildings in the images differ from each other.

John Robinson (1899, 123) used the four terms 1. Mass, 2. Subordinate mass, 3. Details and 4. Horizontal subdivision to describe the compositional elements of buildings:

**Mass**
The mass is the principal geometry of a building. It’s on this mass that the other elements of the building will be added (1899, 6).

**Subordinate mass**
A subordinate mass is any secondary mass that protrudes from the geometry of the principal geometry. Subordinate masses can be dormers, tourelles or oriels (1899, 27).

**Details**
Details refers to other elements that cannot be classed as a subordinate mass such as windows, arches and doors (1899, 50).
Subdivision

The horizontal subdivisions are the buildings horizontal sections or levels as created with mouldings or cornices. The subdivision can also be achieved if the different levels of a building are given different treatment, such as varying window composition or changes in facade texture (1899, 57-67). Vertical subdivision would follow the same standards.

Although Robinsons (1899) elements were an early attempt at breaking down the visual categories of a building, they nonetheless seem to present a valuable model for classification and identification of architectural elements. For example, Rapoport (1990, 273) lists several visual cues in the physical urban environment in regards to buildings, amongst them are: shape, size, height, details, color, materials and texture.

Rapoport's (1990, 276) research points to the elements of the repertoire that are the most likely to be effective. Strong rather than subtle space variations, the texture, color, and geometrical alignment of enclosing elements; height of enclosing elements, and personalization all seem important. When comparing these visual cues to the terms that Robinson proposes they have a lot in common. The visual cues are all factors that makes up Robinsons elements. Rapoport however introduces terms such as enclosure and alignment, something that is achieved by the interplay between buildings, and not the single building in itself.

According to Carmona (2010, 189) there are a number of different volumetric and visual characters that makes up the streetscape. In relation to volumetric characters siting, size/massing and building scale are important aspects. These are all descriptions of a building's overall three-dimensional form and disposition relative to its context. Siting concerns how a building ‘sits’ on its site and its relation to nearby buildings, streets and other urban places. Size/massing refers to the three-dimensional disposition of a building’s volume, in other words, much like Robinson’s mass and subordinate mass. When Carmona refers to building scale he stresses that scale is different from size. Size represents the literal dimension of an object, while scale is the perceived size of the object in relation to its surroundings. The visual characters concerns primarily the design of the building facade. Some of these are horizontality, materials and rhythm. Carmona (2010, 190) argues that most facades have both vertical and horizontal elements, one or the other tends to dominate such that it has either a vertical or horizontal emphasis. Another visual character are the facade materials. The use of different materials can sharpen or soften differences between the various parts of the building and the relation between it and its neighbours. Carmonas horizontality, verticality and materials are closely related to Robinsons subdivision. Rhythm refers to a repeating pattern of the streetscape elements. It concerns itself with things such as the arrangement and size of a building’s constituent parts. Repeated patterns has a strong rhythm, while something that deviates from the repetition breaks up a given rhythm.

Christian Norberg-Schulz (1965, 34), while acknowledging the difference in the architectural elements of mass, subordinate mass, details and subdivision, also approaches the streetscape quantification in terms of ‘wholes’ and ‘elements’. However, this thesis will stick to the
element classification of Robinson, since they allow for analyzation and quantification of a large number of images and has been used in recent studies when exploring complexity (Elsheshtawy 1997). The purpose of identifying the elements is to see what class of elements, if any, have a stronger effect on visual attention than others - especially when it comes to the primary masses that frames the street type and plays a decisive role for the thesis questions.

If we return to the two images A and B presented earlier, and break them down in their constituent parts based on what the thesis have presented, we can see how the environment can be quantifiable, which allows one to better understand the differences in the two images.

**Primary mass**

The primary masses represents the primary volume of the buildings. In the two streetscapes, they are similar with only some differing masses in terms of height and variation.

**Subordinate mass**

The subordinate masses are quite different when you compare the two images. Image A has all of its subordinate masses on the rooftops of the primary mass, while Image B has its subordinate masses along the primary mass facades.

**Details**

Details are elements such as windows and cornices. Image A has cornices and large bottom-floor windows while image B has a few bottom floor windows on one of its sides and lacks cornices completely.

**Subdivision**

The subdivision in the two images are also quite different. Image B has some four discernable subdivisions, while Image A has at least nine.

Robinsons elements, mass, subordinate mass, details and subdivision plus the buildings relations to each other. These are the elements of the fixed feature group. The results of these differences are that despite looking fairly similar from above, and enjoying the same street type, they both vary on a streetscape level. These differences could have an impact on the perception of the perceiver. The effect of the streetscape on human perception will be more elaborated on in the next chapter.
2.4.2. Semi-fixed features and Non-fixed features

As presented before, Rapoport (1990, 26) introduces semi-fixed features as to include furnishing in its broadest sense and narrows it down to examples of elements like signs, vegetation, art and furnishing. Semi-fixed features are very much like what Carmona (2010, 196) calls street furniture, which includes elements like bollards, benches, signs, railings, fountains, public art and countless other items. Semi-fixed features are a part of many, or maybe even most, streetscapes and are acknowledged as a stand-alone feature separate from other features in the streetscape due to their common character as being less fixed than buildings, and more fixed than pedestrians.

Non-fixed features (Rapoport 1990, 96) represents the human occupants, bikes, cars and other vehicles with their common attribute of shifting spatial relations as they move in the streetscape. A sense of motion and movement is tied to these features, which puts them in contrast to the earlier features described in this chapter.

2.5. Perceiving the streetscape

At different places on the earth, different observers will see the moon in a different position and movement in relation to the sun, so that, for instance, while there may be a total eclipse of the sun at one place, it is not so everywhere; here (...) the objective conditions of the appearance are the same, but not the subjective ones, such that the moon's path appears differently.

Gustav Fechner (1801-1887)

We were able to quantify the streetscape in the previous chapter, but, as expressed by Fechner, even if we can look at the environment objectively, the subjective perception might vary. This chapter aims at explaining what current research has found about how the streetscape appears subjectively. The chapter will relate to the structure of the previous chapter where we identified the different constituent parts of the streetscape.

Reality is a complex system not easily reproducible in all its variables and dynamic aspects. Perception refers to a process in which people organize and understand this complex reality through stimuli connected to vision, hearing, smell and touch (Chang 2015; Piga 2013; Carmona 2003). In order to effectively simulate how humans perceive reality one should take all the senses (vision, hearing, smell and touch) into account (Piga 2013, 26). A simulation of this sort takes a lot of expertise in the various sensory organs as well as methods to allow the measurement of all perceptual input, processing and results. Since architecture and the built form is primarily experienced through vision this current study will therefore limit itself to only this sense (Meiss 2913, 13). Donald Appleyard (1976) notes that the visual sense is normally the primary aspect involved when it comes to perceiving the urban environment on a so-called ‘First-encounter reality’. Vision is not just the dominant sense in an urban context, but it also provides more information than the other senses combined. Orientation in space is achieved visually. Vision also sets itself apart from the other senses through the fact that it is an active sense due to its exploratory nature. When
we look, we search, but smell and sound comes to us without effort (Carmona 2003, 111). William Whyte (1980, 58) puts this difference into an urban design context when he states that sightlines are important, because if people cannot see a space, they will not use it - hence, the visual sense is an active and effortful sense.

This study will only recreate a stimulation that activates the visual sense due to the nature of the study - finding whether the visual attention can be predicted from a two-dimensional plan to a three-dimensional realization. Therefore, the remainder of this thesis restricts the meaning of perception to vision.

The research into the perceptual qualities of the urban environment grew out of a context that is best described by Nikos Salingaros (2005, 235):

“I criticize(ed) the arbitrary and non-adaptive design methods in widespread use for the past several decades. Architects who replace historic solutions adapted to human needs with simplistic image-driven typologies reveal(ed) a total lack of understanding for the role of design. They also introduced an arrogance into the profession, which, combined with those non-adaptive design methods, has made the built environment more and more dysfunctional and even inhuman. It appears that despite repeated and well-publicized calls for design according to adaptive principles, these tendencies of contemporary architecture and urbanism show no signs of abating. I believe it is time to rebuild a functional environment that better supports human life.”

The growing field of perceptual research stems for a growing need for adaptive urban design based on scientific understanding and observation. One of the early pioneers of the study of perceptual qualities in the urban environment was Kevin Lynch with his influential book *The Image of the City*. He introduces the concept of imageability, a sort of measurement of the quality in a physical object which determines what ability the object has of evoking a strong image in any given observer (Lynch 1960, 9). In order to increase or strengthen the imageability of an urban environment one should apply the different elements of paths, edges, landmarks, nodes and regions (Lynch 1960, 95). The result of high imageability would heighten the observer’s attention and enrich his experience. Another influential author on the topic is Christopher Alexander with his book *A Pattern Language* (1977). In his work, Alexander presents design problems and design solutions to these same problems. The pairing of the problem and corresponding solutions are collectively called a pattern, and these patterns are the elements of the pattern language. This pairing was made by looking for patterns in human activity and interaction - and analyzing to what extent the built geometry either encouraged or discouraged certain human activities. These different patterns belongs to separate levels in the order of “above”, such as accessible green, or “below”, such as tree places. The levels above are dependent on the levels below, and the levels below are depended on the levels above. This results in an interdependence of different levels and patterns, and when paired together creates solutions (Alexander 1977).

Thus the pattern language is, much like Lynch’s imageability, a way to understand the perceptual quality of the built environment and its effect on the perceiver. Yet another influential scholar is Nikos Salingaros (2005). The pattern language as introduced by Alexander is based on experience on what works and what doesn’t. Salingaros introduces the idea of putting these patterns through the validation of the scientific method (Salingaros...
Salingaros also introduced the term *form language*, which is different from Alexander’s pattern language. While the pattern language contains rules for how humans interact with built forms, the form language consists of geometrical rules for putting matter together (Salingaros 2005, 211). Numerous other researchers have since devoted time to better understand how humans and form reacts to each other, and how the form influences human behavior and perception.

This chapter will now present relevant perceptual research in the order of the four different streetscape features earlier introduced in this thesis: Mass relations, fixed features, semi-fixed features and non-fixed features.

2.5.1. Mass relations

According to Gestalt theory, when we perceive things using our vision, what we are actually doing is that we read figure forms. Meiss (2013, 21) puts it that the “user” of form, i.e. the perceiver of a stimuli, cannot choose freely what he’ll see in a given context. Certain figure forms register more easily than others even before one considers their content or meaning; they become autonomous figures due to their background, or void. Such an elaboration renders it possible to understand what major part the figure-ground phenomenon has for the visual perception. It is important to clarify that, even though the visual sense is a searching one, the perceiver cannot always choose what parts of reality is being perceived. Understanding what influences the perception of a person in a given context is what the Gestalt theory demonstrates.

Coherence

This thesis is primarily concerned with visual attention. For this reason only the major principle that have hypothesized effects on visual attention will be taken into consideration in the study. Yu-Fei Ma (2003, 375-376) hypothesizes that contrast is the common denominator for attracting visual attention. The supposition is being made by comparing different images, as follows:

![Image](https://via.placeholder.com/150)

*Figure 12. Images used to illustrate the concept of contrast. Image courtesy of Ma (2003).*

Figure 12 consists of six images, where the upper three images are variations of the bottom three images. First we look at images (a) and (b). The assumption goes that bright color attracts attention, which would be supported by image (a) where the visual attention would primarily concern the small red square. This, however, does not hold true for image (b) where the attention is primarily on the small black square. Instead, we would be perceiving
the smaller square as a figure on a background, being a smaller element that is a part of a bigger context. Image (c) and (b) demonstrates that the strength of a texture does not overtake the attention influence that contrast has. Images (e) and (f) demonstrates how complexity of a figure do not capture the visual attention as much as the contrasting figure. The idea that contrast effects visual attention is also supported by earlier eye tracking studies (Horsley 2014, 185).

The understanding of contrast as a phenomenon that influences visual attention is also explored by Cullen (1971, 44). Cullen puts the concept of contrast in a streetscape environment and calls it *incident*. He describes incidents as slight deviations from the overall relative symmetry, be it in height (silhouette features), change in color or material. Moughtin (2003, 58) finds that while coherence, or rhythm, is important to achieve, it can also fall in the trap of monotony. He therefore prescribes *contrast* as a form of capturing interest or creating accent in the streetscape. Heath et al. (2000) also found that complex building silhouettes (meaning changes or contrasts in the figure) had a strong influence on preference, arousal and pleasure.

Due to the findings of previous researchers that points to coherence and contrast as having abilities that influences perception, it seem to be highly relevant to include coherence as a principle that will be used to analyze this thesis’ results. Coherence relating to the coherence of composition, not just in alignment, but also in texture, color and size - contrasting elements from the overall coherence in general. This thesis will not make use of Günays *symmetry* term or its other alternative term *rhythm*, but instead the term *coherence* will be used, due to this being a commonly used term in current urban design literature when describing the similarities and identifying contrast within a context (Carmona 2003; Meiss 2013; Kaplan and Kaplan 1989; Chang 2015; Ewing 2003; Ewing 2006; Nasar 1994).

If we return to image A and B, it is possible to see the principle of coherence in action. The coherence in image A is broken up by the towering figure in the middle of the picture, seemingly breaking up the pattern of the image, thus drawing attention to itself as a stand-out feature. In image B, there is a difference in figure height that is breaking up the coherence, though, in a much more subtle way than in image A. Thus, one could assume that image B does not have any particularly strong figures that would obviously attract attention. However, the towering figure in the image could be predicted to draw attention to itself due to it not partaking in the general coherence of the image and creating a strong contrast, which has previously been shown to influence visual attention. Thus, In this thesis
coherence refers to a sense of visual order. The degree of coherence is influenced by consistency and complementarity in the scale, character, and arrangement of buildings.

2.5.2. Fixed features

As has been shown, contrasts at any level are likely to capture the visual attention of the perceiver. But there seem to be evidence suggesting that some specific elements in the streetscape may influence visual attention more than others. Drawing upon the findings of Chang and Ching-Horng (2015, 16), they found that visual attention is primarily focused on the vanishing point - that is at the horizon as revealed of the void in-between solids.

![Figure 13. Focus on the vanishing point and signage. Image courtesy of Chang and Ching-Horng (2015)](image)

Apart from the vanishing point, a plethora of different fixed feature elements may influence the visual attention, and it has already been acknowledged that not all hypotheses that may influence visual preference or attention can be taken into account in this thesis.

Rapoport (1980, 257) found that the age or style of buildings is less important and that relationships are more important than the nature of the elements, such as primary mass, subordinate mass, etc. Elements may be important in terms of their effect on the perceptual character of the setting. For example, they may be important in terms of the texture or richness of the buildings, that is, the enclosing elements. This can be inferred from preferences for three-dimensional facades, which could help explain an eventual focus on subordinate masses protruding from the primary mass.

As for the fixed feature element of subdivision, Carmona (2010, 190) states that although most facades have both vertical and horizontal elements, one or the other tends to dominate such that the facade or primary mass has a vertical or horizontal emphasis. As the constituent parts of a building’s facade traditionally had a vertical emphasis, buildings with strong horizontal emphasis tend to disrupt the visual rhythm. As the combination of buildings with horizontal emphasis and the horizontality of the street can result in excess horizontality. Carmona claims that the general principle is that urban buildings have a vertical emphasis to which the street provides a balancing horizontality. Carmona also suggests that horizontal lines are visually faster than vertical lines, as the eye runs more quickly along them. As the eye is detained for a shorter amount of time in an excessive horizontal streetscape, the streetscape tend to be less interesting. We could therefore assume that the horizontality and verticality of the fixed features in the streetscape can influence how the eye moves.
Salingaros (2005, 44) introduces the concept of the spatial information field. The information field is decided with two measurements, namely content and accessibility. Content is the measurement of the described, for example the message of a text on a page, whereas accessibility is the effort needed to receive a given piece of information, for example how easy it is to read the page. In urban design context, and in relation to this thesis, these concepts can be better explained with the use of the following images.

In the two images above the primary mass of the terminating building show the same amount of accessibility. They are both right in front of the perceiver and can be read easily, this is in contrast to the surrounding buildings that are not perpendicular to the perceiver, but rather parallel, and are thus less accessible. However, there is a clear difference in terms of content between the two terminating buildings in the pictures. The left picture has a comparatively small amount of content.

The accessibility is directly related to the primary mass and its alignment, while the content is directly related to secondary masses and details. This difference is relevant to this thesis since the detailed development plan controls the accessibility (primary mass), but have very little, or perhaps no, control of the content (secondary mass and details). If there is a difference between the attraction of the visual attention between the detailed development plan and reality, the content could be a deciding factor.

2.5.3. Semi-fixed features and Non-fixed features

Semi-fixed features are a part of many, or maybe even most, streetscapes and are acknowledged as a stand-alone feature that is separate from other features in the streetscape due to their common character as being less fixed than buildings, and more fixed than pedestrians or cars. The nature of the semi-fixed feature category is that it contains so vast amount of different elements that it is important to acknowledge that the elements, despite their common trait based on fixation, are also different in terms of perception.

Signage

Chang and Ching-Horng (2015, 16) found that signage and text captures the attention consistently when they conducted their eye tracking experiment in commercial districts. Signage is usually a contrasting element in the streetscape with color and text whose very
purpose is to capture the attention of passers-by. It is likely, based on the findings of Chang and Ching-Horng that signage will affect the visual attention in the streetscape.

Greenery
Edward O. Wilson (1984) hypothesized in his book *Biophilia* for human’s natural attraction to other living things. This attraction has been shown to hold some interesting perceptual predictive qualities in the streetscape as well. Rapoport (1980, 257) reports of a study of a walk in downtown Seattle which showed that in addition to neatness, tidiness, and lack of visual chaos, pedestrians preferred considerable amounts of foliage. Moreover, because pedestrian spaces for walking may be related primarily to interest, whereas settings for static activities may be more related to liking, it follows that for walking, perceptual qualities plays a larger role than for sitting where associational qualities become more prominent. As already suggested, this should lead to greater preference for natural environments and it has in fact be shown that for static spaces, greenery is highly important (Purcell & Thorne 1976).

John Rollo and Suzanne Barker (2013, 1) conducted an experiment whereby they put participants through a spatial sequencing process, comparable to serial vision, and asked the participants to judge each scene's favourable and unfavourable perceptive qualities. Their study highlights the important qualitative effect that green attributes brings to the streetscape. Rapoport (1977, 317), however, stresses that he is not suggesting that greeneries visual qualities are the only reason for this attraction. The presence of large trees has positive effects on temperature, sound, dust and other environmental characteristics. But associational preferences for trees are present. They may be general, because trees are part of human associations, or culture-specific and due to experience, such "good" areas tend to be associated with many large trees and bad areas with their absence. Thus, people's responses to environments partly depend on where they grew up or come from.

By being common elements in the streetscape as well as having favourable perceptive qualities it is likely that greenery also has an effect on the human visual attention and will therefore be used in analyzing the results of the present experiment.

People
Just as with trees and bushes, people are likewise living things that may cause attraction of visual attention. Perhaps the most noted author that puts forth this idea is Jan Gehl (2010, 52, 64) who equates crowded places with more interesting places. Gehl proposes that the life in a city is a self-reinforcing process; “Something happens because something happens because something happens”. If a place is perceived as being used, due to people being present and activities taking place, it is likely to attract people. Rapoport (1980, 268) also concludes from his research that people have a general preference for crowded areas. He is however concluding this based on research in complexity, and acknowledges that this preference is not fully understood, but can be predicted nonetheless. Since people are frequent elements in the streetscape, it is important to acknowledge the possible effects that the presence of people might have on the visual attention.

Lastly, it is important to end with saying that the task of identifying the visual or spatial attributes of a streetscape has proven problematic (Alexander 2003). Despite reliance on
expert evaluation, the analysis of a streetscape is essentially an individual’s interpretation of what appears to be visually significant. However, the thesis has grounds to assume that specific elements are likely to affect the visual attention of the perceiver, as has been described in this chapter. It’s important to note that this thesis assumes that visual preference influences visual attention. The thesis is not holding this to be true, nor is it depending on it for the purpose of the study. However, it is likely to help in analyzing and explaining the resulting data and why, how and if visual attention shifts.

2.6. Eye tracking research

*What counts… is the position of the spectator and the direction in which he is looking. Only that which a spectator can hold in view, what can be seen, is of artistic importance.*

*Camillo Sitte (1843-1903)*

This chapter intends to explain the basic functionality of the eyesight as well as presenting earlier research on the topic of eye tracking. These basics are provided in order to better understand and explain the workings and criticism to eye tracking experimentation in general.

2.6.1. Visual attention

Visual attention, which is the dependent variable in the experiment of this thesis, represents eyesight focus, or point of gaze. Duchowski (2007, 11) presents a so called bottom-up concept of visual attention made up of three cyclical steps:

1. Given a stimulus, such as an image, the entire scene is first seen mostly in parallel through peripheral vision and thus mostly at low resolution. At this stage, interesting features may “pop out” in the field of view, in a sense engaging or directing attention to their location for further detailed inspection.
2. Attention is thus turned off or disengaged from the foveal location and the eyes are quickly repositioned to the first region that attracted attention.
3. Once the eyes complete their movement, the fovea is now directed at the region of interest, and attention is now engaged to perceive the feature under inspection at high resolution.”

*Figure 14. A simple explanation for the relevant workings of the eye in the context of an eye tracking study.*
This concept suggests that the peripheral vision which has the extent represented by the field of view, allows the viewer to notice stand-out objects to which the fovea is directed, which results in the point of gaze, which in turn provides a high resolution inspection of said object.

However, an eye tracking device can only track the visible movements of the eyes, however, it cannot track the covert movement of visual attention. Thus, an important assumption is usually accepted: It is assumed that visual attention is linked to foveal gaze direction, but it is acknowledged that it may not always be so (Duchowski 2007, 12). This thesis accepts this same assumption.

The selective nature of visual attention is represented by the “what” and the “where”. The “where” of visual attention corresponds to the visual selection of specific regions of interest from the entire visual field. This selection is carried out through the aid of peripheral vision (Duchowski 2007). The “what” of visual attention corresponds to the detailed inspection of objects within the specific region of interest, see figure 14. The “what” and “where” duality is relevant to eye tracking studies because eye movement show the progression of the observer’s foveal direction of gaze and therefore depict the observer’s immediate visible localization of visual attention. If one wishes to view an object in fine detail it is required that the eyes move to bring said object within the point of gaze so that it can be investigated in fine detail. We are thus moving our eyes to bring a particular portion of the visible field of view into high resolution so that whatever is capturing our attention can be investigated in high resolution. Thus, we presume that if we can track someone’s eye movements, we can also track the attention of the perceiver. This would give us insight into what the perceiver found interesting, or in other words, what attracted their visual attention.

Figure 15. The difference between point of gaze and peripheral view can be showcased by looking at the image above. When the fovea is directed to one of the dots, the rest of the dots are within the peripheral vision and are slightly distorted. Only when the fovea is directed at a specific region on the image does the distortion disappear.
In short, visual attention is a term that refers to where the point of gaze is located. This thesis will focus on what attracts the point of gaze - i.e the foveal gaze direction.

2.6.2. Previous research

Due to recent improvements in eye tracking technology, studies using eye tracking are relatively new. The hardware that captures eye movements is now non-intrusive and more accessible compared with prior devices (Duchowski 2007). The majority of these early studies were conducted in the field of psychology. This research was crucial to laying the foundation for the expansion of eye tracking approaches, which allowed the technology to be used to study other domains of interest. More particularly, early psychology studies determined that eye movements are related to visual attention, and permitted researchers to develop understandings of how to measure eye movements by recording point of gaze (Noland 2016, 100; Horsely 2014).

![Figure 16. Points of gaze on a picture showing Sofiakyrkan, Jönköping. The hotter the color the longer the time spent perceiving the region.](image)

What determines what one looks at could be due to many variables. For example, previous research has shown results that seem to show some differences in exploration strategies between women and men. Women tended to adopt the systematic inspection strategy more often than men, and were more interested in different parts of the scene, but given the small sample available, these tendencies were to be considered as indications (De Lucio et al. 1996). Lucio also found that the observation patterns detected could be related to landscape appraisal factors. Kim et al. (2013, 92) would later confirm this by showing a relationship between high preference and longer fixation times on specific points. What could influence preference in an urban planning context has previously been laid out in chapter 2.5. Hence, it is important that these appraisal factors gets incorporated into the analysis. Noland (2016, 86) takes note that they struggle to find a method that allows for understanding the users’ unconscious desires as they look at certain elements. Though many variables could be taken into account, and the relationship between appraisal and point of gaze are not fully established, this thesis will note down the participants’ sex, age and ethnic background. This thesis also assume that perceptive qualities of streetscape features as described in chapter 2.5
could impact the visual attention, even though the “how” or “why” are not yet fully established.

A factor that has been shown to interfere with the predictability of the point of gaze, or visual distractions, has been that of visual overload (Horsely 2014, 12). Horsely notes that visual distraction appears to influence eye movement behaviour. Results from prior studies indicate that an increase in the visual content of the image scene results in slower saccade peak velocities. Saccades being the rapid eye movements used in repositioning the fovea to a new location (Duchowski 2007, 42). In urban design terms, this increase of content which results in visual overload can be equated to the term complexity (Meiss 2013, 48), meaning a richness of content in an environment. Complexity will however not be methodically incorporated into this thesis as it requires too much resources for the scope of this study, but various methods have been tried to calculate the complexity of an urban space (Elsheshtawy 1997). The study could however still make rudimentary assumptions whether an image has more or less content that other pictures, this will be done throughout the analysis of the eye tracking data.

As for the amount of participants needed, Gunawardena et al. (2015) used still images in their study on structural hierarchical visual complexity of streetscapes. The stimuli in this study comprised of 60 still images that with the human perception of 20 participants were classified into figures and backgrounds. The study concluded that visual complexity is generally higher in dense areas as opposed to sparsely urbanized areas. Similarly, Rollo & Barker (2013) also used 60 still images of streetscapes and 30 participants who were asked to evaluate a streetscape experience based on favourable and unfavourable perceptive qualities. The study highlights the importance of the effect and quality of green attributes within the overall streetscape experience. Cavalcante et al. (2014) uses 74 still images of streetscapes that were ranked in terms of complexity by 40 participants. Noland et al. (2016, 100) showed 40 images to 20 participants as they investigated visual attention and preference towards objects in different environments. In comparison, this study will show 40 images to 15 subjects. While with more participants, the results are likely to be more robust and the power of the study higher, according to Kim (2006), 5 to 10 subjects are needed, generally, in experimental research involving people’s physical functioning.
2.7. Analysis tools

We have established what the streetscape consist of and how its features and elements influences our perception of it, and perhaps our visual attention. These features are grouped in four categories: Mass relations, fixed features, semi-fixed features and non-fixed features.

Each of these four categories possesses qualities that are thought to influence the human visual attention. This thesis is primarily concerned with how the mass relations and fixed features impacts people’s visual attention, but will have to take all of the above into account. Each streetscape will therefore be analysed through the matrix below. This quantification process allows us to conclude whether there are any indications of predictability of the visual attention when planning new street environments based on a two-dimensional map.

<table>
<thead>
<tr>
<th>Features</th>
<th>Figure image result</th>
<th>Photo image result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass relations</td>
<td>Description</td>
<td>Description</td>
</tr>
<tr>
<td>Fixed features</td>
<td>Description</td>
<td>Description</td>
</tr>
<tr>
<td>Semi-fixed features</td>
<td>Description</td>
<td>Description</td>
</tr>
<tr>
<td>Non-fixed features</td>
<td>Description</td>
<td>Description</td>
</tr>
</tbody>
</table>
3. Method

The previous chapter produced the theoretical context in which this study will ask its questions, as well as providing analysis tools. These analysis tools are used to produce quantified data from the otherwise qualitative results of an eye tracking experiment. The justification and details of the experiment is detailed in this chapter.

3.1. Experiment

The purpose of the thesis is to explore whether two-dimensional maps have predictive abilities concerning humans visual attention as the participants are faced with different street types. In order to achieve this it is valuable to apply a method that is able to measure the physiological and automatic reactions, that might be shared among the general population. In order to gather data on the automatic reactions of the eyes when facing a stimuli it is necessary to capture eye movement in some way. This is done with the use of an eye tracking device. Since the thesis main driving force is to find a possible causation between different street types and visual attention it is appropriate to conduct an experiment with defined independent variables and dependent variables (Denscombe 2009, 75). It is important that the factors of interest are constant in the stimuli so that any change in the measured data can be attributed to the specific factor (Denscombe 2009, 75), this specific factor is called the independent variable (IV). The IV is achieved by carefully choosing stimuli that includes the phenomenon of one of the four specific street types. In order to make an accurate causation, it’s important to identify the various factors that could influence the participants, as well as isolating the phenomenon of interest, as is the case by making them constant throughout the stimuli. The dependent variable, or DV, is the phenomenon that is assumed to be influenced by the IV (Bryman 2012, 54). The DV in this thesis is visual attention. The assumption that visual attention is influenced by different street types and streetscape content was explained in chapter 2.5. The experiment is a suitable method in order to answer the thesis’ questions. More on the IV and DV can be read in chapter 3.3. Since the main questions are answered by investigating a causation between IV and DV, and that the IV can be manipulated makes the experiment a valid choice of method.

Bryman (2012, 50) makes a distinction between field experiments and laboratory experiments. The laboratory experiment takes place in a contrived setting while the field experiment occur in real-life settings, such as classrooms. The laboratory experiment allows the researcher to have greater influence over the experimental arrangements. In order for the participants to use the eye tracking device in a correct way, the amount of research influence on the arrangement is crucial for producing reliable results. Since the arrangements are controlled by the researcher to a high degree in the laboratory experiments, the setting can be easily reproduced by other researchers (Bryman 2012, 55). Given the necessity to conduct this research through an experiment, and due to the fitting nature of the laboratory experiment, this thesis will make use of the laboratory experimental method. This means that the experiment is conducted in an undisturbed location with little outside influence, rather than in “real-life” (Denscombe 2009, 81, Bryman 2012, 50). How the setting and setup looked like can be seen in image 7 in chapter 3.3.
The experiment method do have some drawbacks that needs to be mentioned and taken into account. There is an inherent reactive effect of experimental arrangements. The subjects in the study are frequently or invariably aware of the fact that they are participating in an experiment. This awareness can influence how they respond to the experimental treatment and therefore affect the generalizability of the findings, since they might have reacted in a different way were they in a more relaxed situation (Bryman 2012, 54). There is also an obvious drawback with the study as the stimuli is presented on a monitor, as opposed to the participants experiencing the environment in reality.

3.2. Stimuli

The stimuli can be presented to the subject using different mediums; On-site, virtual reality, pre-recorded videos and still images. The choice of presentation technique will depend on the purpose of the thesis and its method. The purpose of the thesis is to study whether visual attention can be predicted from figure images depicting different street types. It is therefore important that the presentation technique enables the use of a quantification and categorization process so that different street types can be identified in the stimuli. It is also advantageous to have several different stimuli so that the results produced will be less dependent on the specific content of each unique stimuli and therefore more generalizable (Bryman 2012, 176). The presentation technique also has to be compatible with an eye tracking device that itself requires the subject to sit relatively still within a determined distance from the apparatus (the device is covered in more detail in chapter 3.3. Given the outset of the method the stimuli will be presented using still images.

Still images have been used in a wide array of studies that investigates qualities in the depicted environment (Ewing & Clement 2005; Elsheshtawy 1997; Gunawardena et al. 2015; Rollo & Barker 2013; Tucker et al. 2004; Cavalcante et. al. 2014; Noland et al. 2016). It’s important that all the images used in the study are captured in an identical way. Badland et al. (2010) tested whether Google Street View provided a resource-efficient and reliable alternative to physical on-site response production to visual stimuli. The study audited 48 streetscape segments both virtually and physically, this process was conducted by one researcher.
In total 11 physical elements in each streetscape were audited by the researcher:

<table>
<thead>
<tr>
<th>Factor</th>
<th>Element</th>
<th>Physical audit score</th>
<th>Virtual audit score</th>
<th>ICC</th>
</tr>
</thead>
<tbody>
<tr>
<td>While walking</td>
<td>Walking surface</td>
<td>1.20</td>
<td>1.24</td>
<td>0.95</td>
</tr>
<tr>
<td></td>
<td>Neighborhood permeability</td>
<td>0.61</td>
<td>0.62</td>
<td>0.60</td>
</tr>
<tr>
<td></td>
<td>Walking infrastructure</td>
<td>0.16</td>
<td>0.14</td>
<td>0.94</td>
</tr>
<tr>
<td>Function</td>
<td>Streets (lanes)</td>
<td>0.22</td>
<td>0.22</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>Fixed traffic controls</td>
<td>0.05</td>
<td>0.04</td>
<td>0.21</td>
</tr>
<tr>
<td></td>
<td>Path safety</td>
<td>0.45</td>
<td>0.42</td>
<td>0.94</td>
</tr>
<tr>
<td></td>
<td>Traffic safety</td>
<td>0.12</td>
<td>0.08</td>
<td>0.84</td>
</tr>
<tr>
<td>Safety</td>
<td>Streetscape aesthetics</td>
<td>0.60</td>
<td>0.59</td>
<td>0.99</td>
</tr>
<tr>
<td></td>
<td>View aesthetics</td>
<td>0.66</td>
<td>0.66</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>Subjective walking assessment</td>
<td>0.23</td>
<td>0.25</td>
<td>0.95</td>
</tr>
<tr>
<td>Aesthetics</td>
<td>Land use mix</td>
<td>2.46</td>
<td>2.68</td>
<td>0.62</td>
</tr>
</tbody>
</table>

The level of agreement between the different audits were calculated using intraclass correlation coefficients, ICC. The ICC scores were categorized as follows: 0.0–0.20 (weak agreement), 0.21–0.40 (poor agreement), 0.41–0.60 (moderate agreement), 0.61–0.80 (substantial agreement), and 0.81–1.00 (almost perfect agreement). An ICC of 0.70 of higher were considered an acceptable measure of reliability. Thus, the level of agreement was acceptable for 8 of the 11 elements. All aesthetic elements had an almost perfect agreement - these are the primary elements that concerns this thesis.

This chapter has presented prior research using still images as valid substitutes to on-site visits. Google Street View has an almost perfect agreement to on-site visits when it comes to aesthetic perception of the viewer. It should be noted that the photos presented in Google Street View are always captured from the middle of the street. This ensures that all photos are taken from the same position within all streetscape stimuli which helps with the comparability of the results produced by the experiment.

The images chosen will have the requirement that they depict streets with one of four different street types, these street types are provided below. The street type in each stimuli will ensure that the results can be comparable and that general results can be attributed to a given street type, and thus the predictive abilities of the figure image, or detailed development plan, can be discussed. The street type will be the primary focus when choosing image stimuli - in other words, the focus will be on the street type, and not trying to encompass all elements and features described in this thesis. Some images will have an abundance of all elements and features, while others only have a few. This thesis will focus on four identified street types common throughout scandinavian cities. The commonality of these street types are decided by the historical overview of street planning, as well as
personal studies of city street maps based on figure-ground and Gestalt theory. However, it is important to note that the street types used in this thesis are likely not all the types of streets you would encounter throughout Scandinavian cities. The name of each street type used in this thesis will be based on what sort of vista it offers. The following street types will be used throughout the thesis; Open, blocked, blocked, curved and angled. They will be presented in more detail below. It’s important to note that novelty towards a specific streetscape can play a role on how the participants looks at images. By only focusing on Scandinavian cities, in terms of streetscapes, the effect of novelty is assumed to be minimized, as widely different architectural styles are avoided.
3.2.1. Blocked street type

Typical street type with blocked vista. Hollendergata, Fredrikstad, Norway.

1. solid
2. solid
3. solid
void

Common in both medieval and baroque cities, the blocked street type has a presence in many cities but is more closely related to the baroque grand manner city planning designs. The blocked street have two solids that runs parallel to each other, creating the enclosure around the void. The void is interrupted by the addition of a terminal solid at the end of the dominant axis. Thus, the blocked street type have three enclosing solids. The terminal solid is positioned approximately 40-50 meters from the position of the camera. The inherent accessibility of the terminating solid facade is high in this street type due to the terminating building showing its facade in a near perpendicular angle to the perceiver, whereas the surrounding solids have low accessibility as they are angled in such a way that their facades allows for a comparatively smaller amount of information (Salingaros 2014, 45). Gordon Cullen (2010, 43) also identifies this type of street by the vista that it allows, dubbing it a ‘closed vista’. This street type can be compared to Tranciks axial street type in figure 5.
2.3.2. Open street type

During the 17th century the term ‘regulate’ became widespread in continental Europe. By consensus, back then, the state needed to regulate its city’s administration, a notion that stretched to also include the city’s physical appearance. The regulated physical appearance of cities were especially prominent in Sweden, where grid layouts became the new norm when founding new cities, as well as when rebuilding already existing ones (Hall 1998, 22). Today, it is hard to find many exceptions to this norm when traveling between Swedish cities. The street type that allows for this sort of open vista is characterized by enclosure on both side of the street. The two solids that creates the enclosure around the void runs parallel to each other. But, unlike the blocked street type, the open street type lacks a terminating building. Therefore the two solids creates a continuous unbroken pattern of straightness. The inherent accessibility of the solid facades are low in this street type as they are angled in such a way that the information field is reduced (Salingaros 2014, 45). It can be compared to Tranciks grid street type in figure 5.

Figure 18. Terms used when discussing the open street type.
2.3.3. Curved street type

This street type is common in irregular cities with a medieval heritage. Most Scandinavian cities with irregular street patterns are located in Denmark and Norway, with only a few examples remaining in Sweden. Unlike the previous street types, the curved street’s two solids that runs along the dominant axis are not parallel to each other, but rather forms a continuous pattern in the form of a curvature - one solid being concave and the other being convex. While curved streets do not have a separate terminal solid to limit the vista, the curvature of the concave solid that align the void achieves this limiting effect. The inherent accessibility of the solid facades are low in this street type except for the very far away facades along the concave facade line that is more accessible than the other facades. Cullen (2010, 44) calls this phenomenon ‘projection and recession’. Instead of the eye taking in the street in a single glance, as it would in a street with perfectly straight facades, it is caught up in the intricacy of the meander. This street type can be compared to Tranciks curvilinear street type in figure 5.
2.3.4. Angled street type

Typical street type with angled vista. Østergravensgade, Aalborg, Denmark.

1. solid
2. solid
3. solid
- void

This street type is common in both irregular medieval cities as well as in and baroque cities with diagonal streets. Like the two previous street types, the angled street type also shares their common attribute being enclosing a void by two solids that runs parallel along the dominant axis. The angled street also has, like the blocked street, a third enclosing solid that terminates the dominant axis. This third solid is however not perpendicular to the dominant axis, but rather angled in relation to it. The inherent accessibility of the terminating solid facade is high, but comparatively lower than in the blocked street type. Cullen (2010, 43) calls this angular silhouette a ‘deflection’, as though the third solid deflects one's expectations along its implied direction. This street type can be compared to Tranciks angular street type in Figure 5.

**Figure 20.** The terms used by describing the two street angles are derived from the exterior angle theorem. The street running “along” the angle of the street is called the *exterior turn*. This is the bigger angle of the two. The street that runs “against” the angle of the street is called the *interior turn*, as it is inside of the imaginary triangle.

**Figure 21.** Terms used when discussing the angled street type.
3.3. Stimuli representation

Each specific streetscape stimuli in this study will be represented in two ways - one photographic and another with only their masses shown, in this thesis referred to as a figure image, as to simulate what a two-dimensional detailed development plan would suggest in terms of building and street footprint, building height and roof angle (see chapter 2.1). Note that the researcher do not have access to the detailed development plans for each of the stimuli presented here. The figure image is instead created with the photographic image in mind, and what in the photographic image that would be expected to be regulated in an imaginary detailed development plan.

![Fig. 22. Detailed development plan](image1.png) ![Fig. 23. Figure image](image2.png) ![Fig. 24. Photographic image](image3.png)

The way this study chooses to represent the primary masses and void could have an impact on how the subjects looks at the stimuli. There are no neutral ways of representing a three-dimensional image of this kind that has come to the researchers attention. However, the reason for representing the image in the colors as shown in the above picture stems from an interpretation of what could be a close-to neutral representation. Moughtin (2003, 225) gives the example of a common figure-ground image, where the solids are black and the voids are white. This sort of representation would draw attention to the black solids, who appears to be more discernable than the white voids. By inverting the colors we get black voids and white solids, this, Moughtin observes, provides more attention to the voids and the relation between the solids. Therefore, this study assumes that by making the solids and voids the same color both would get equal attention. It is however not appropriate to make all elements in the photo in the same color, as in both a three-dimensional world and a two-dimensional world, the street is clearly discernable from the buildings that aligns it. Therefore the sky, street and buildings have different colors. The street has the more dominant color of the three as the void and the relations between the primary masses are of interest to the study. Apart from the actual primary masses, some other fixed elements that align the streets, such as brick walls, will also be treated as primary masses in order to contain the void as per the photographic image.

This study will represent the sky with a white color (#FFFFFF), the building masses with light gray color (#BFBABA) and the streets with a darker gray color (#7F7F7F).
3.4. Eye tracking experiment

As explained in chapter 2.6, the eye tracking experiment allows us measure the visual attention of subjects. This chapter explains how the eye tracking experiment was executed. Duchowski (2007) lists are couple of reports the researcher has to do when they use an eye tracking device in order to make sure that the experiment can be replicable: Hypothesis (or assumptions), Design, Participants, Apparatus, Procedures and Tasks. The assumptions and previous research this thesis takes into account have already been showcased in the research framework, chapter 2.

3.4.1. Design

Design refers to how the experiment is conducted in terms of independent variables and dependent variables (Duchowski 2007, 158). The independent variable (IV) is the element in the experiment that undergoes manipulation throughout the different stimuli. In this study the IV is the street type. The perfect experiment should showcase stimuli where the IV is the only variable between different stimuli. However, given that this experiment revolves around photographic stimuli in an urban center environment it is difficult, if not impossible, to make sure that only the street type is the IV. This is because other elements such as architecture, signage position or people presence will be different from stimuli to stimuli. In order to combat this the experiment will not simply use one stimuli per street type, but five stimuli per street type. This would increase the probability that whatever the result of visual attention is, it could be connected to the IV that is constant throughout all four stimuli, namely the street type, as opposed to signage or people. The dependent variable (DV) is what is assumed to be affected by the IV (Duchowski 2007, 158), in this case, the DV is visual attention.

3.4.2. Participants

The participants are recruited by the researcher by walking around looking for willing subjects in the local library. Posters were also put up in said library and the local university and culture house. The researcher actively tried to recruit a mixed population in terms of age, sex and ethnic background to the extent that it was possible, this was done to better reflect the general population. One shortcoming that is inherent in the laboratory experiment is the fact that the recruited participants have to be volunteering, the shortcoming arises due to the the possible differences in the responses of volunteers and non-volunteers (Bryman 2012, 55). The participants were also given incentives to participate in the form of monetary reward, which could further demarcate them from the general population since not everyone is equally amenable to the same inducements. However, the majority of the participants turned down the monetary reward and volunteered for free.

Fifteen participants participated in the study, this is less than the general number of 20 participants in other eye tracking studies. The age range varied widely which could add to the generalizability of the results and the male/female ratio was 1:2, which makes this study more influenced by males than by females, this would in turn decrease the generalizability of the results (Bryman 2012, 54). The study were also heavily influenced by subjects from
sweden, whereas only three foreign subjects participated, all of which were males. The relatively low amount of participants also influences how generalizable the conclusions made from the study can be, but also limits the ability to compare the results with other studies on the topic.

Duchowski (2007, 160) names demographic data such as age ranges and gender distribution as important reports to make. The relevance of this demographic data is supported by the indication of gender differences in eye tracking studies (De Lucio et al. 1996). The relevant information about the participants in this study can be found in the table below.

<table>
<thead>
<tr>
<th>Subject #</th>
<th>Sex</th>
<th>Age</th>
<th>Background</th>
<th>Eyesight correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Male</td>
<td>68</td>
<td>SE</td>
<td>Farsighted +3</td>
</tr>
<tr>
<td>2</td>
<td>Male</td>
<td>17</td>
<td>SE</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Male</td>
<td>31</td>
<td>SE</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Male</td>
<td>31</td>
<td>AE</td>
<td>Farsighted -1</td>
</tr>
<tr>
<td>5</td>
<td>Female</td>
<td>38</td>
<td>SE</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Male</td>
<td>32</td>
<td>SE</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Female</td>
<td>28</td>
<td>SE</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Female</td>
<td>52</td>
<td>SE</td>
<td>Farsighted +3</td>
</tr>
<tr>
<td>9</td>
<td>Male</td>
<td>63</td>
<td>SE</td>
<td>Farsighted +2</td>
</tr>
<tr>
<td>10</td>
<td>Female</td>
<td>27</td>
<td>SE</td>
<td>Nearsighted +4</td>
</tr>
<tr>
<td>11</td>
<td>Male</td>
<td>28</td>
<td>SE</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Male</td>
<td>73</td>
<td>SE</td>
<td>Farsighted +3</td>
</tr>
<tr>
<td>13</td>
<td>Male</td>
<td>25</td>
<td>SY</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Male</td>
<td>25</td>
<td>SY</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Female</td>
<td>28</td>
<td>SE</td>
<td></td>
</tr>
</tbody>
</table>

Table 3. Participant data. Showing sex, age, background and eventual eye sight correction.

3.4.3. Apparatus & software

The eye tracking apparatus used in this study uses a point grey camera and infrared lights to illuminate the scene and to compute the point of gaze. There are two main methods that the infrared lights can more easily track the pupils of a subject's eye, either through dark pupil registration or bright pupil registration. If the tracker uses the dark pupil registration the
chance of other dark features in the face such as eyebrows, nostrils or eyelashes have an increased chance of capturing focus away from the pupil. The device used in this study uses the bright pupil method, which creates more contrast between the dark features of the face. The device makes use of a camera that has a resolution of 752x480 pixels with a sampling rate of 60 Hz. It has a visual angle frequency of 0,5-1° with an operating range of about 50 cm. This means that the subjects has to be within range of the device in order for the collected data to be reliable. The device is compatible with 24” displays or smaller, the monitor used in this experiment is 23,6” with a 60Hz sampling rate. The monitor presents the stimuli in 1920x1080 pixels resolution. The eye tracking-device requires its host computer to use windows OS, have at least 8 GB RAM and intel Core i5 or faster, all these requirements are met. The software used is OGAMA 5.0, which is an open source software that allows recording and analyzing of eye and mouse tracking data collected from slideshow-based eye tracking experiments. The image stimuli are presented with the software in a slideshow and allows the eye tracker to measure the point of gaze on each separate image.

3.4.4. Procedure

Prior to the experiment the participants are informed about the amount of stimuli and estimated total time of the experiment session. The participants first reads through and fills in the form of consent (see Appendix 2). They also reveal their sex, age and ethnicity which will be noted down. New systems tend to use an auto-focusing digital camera, e.g., embedded in a flat panel display. Although embedding within a flat panel display may restrict a user’s physical position somewhat, it is generally preset to operate at a comfortable range (Duchowski 2007, VI). For this experiment the range is 50 centimeters, as outlined before. The participants will be seated within this range prior to the calibration process. When the participants are in place a five-point calibration session ensures the quality of the eye-tracking experiment.

In total 40 images are shown. Each image is presented for 10 seconds with a 1,5 second gray (#5C5B5B) screen shown in-between to minimize carry-over effects from image to image. The gray screen also has a light gray (#9C9B9B) crosshair in its center so that the eye gets attracted to this point. This results in the eye starting from the same point for each stimuli shown. The 40 images are sorted in five different slideshows (see Appendix 1). These slideshows are shown in different order to different participants as to make sure that the pattern of the images is not at fault for any unusual results. After each 10 image shown the five-point calibration will be redone in order to prevent human error caused by accidental head movements that may interfere with the prior calibration. In total four calibrations will be done for each participant.

Noland (2016, 108) holds that many studies that use eye-tracking analysis focus on the heat maps produced. These also provide information on what elements respondents fixate on, but results cannot be easily quantified. Just like most studies focused on eye tracking, this thesis will produce a heat map and the quantification will be done through the table introduced in chapter 2.7 When the experiment is done the participants gets a chance to ask more in-depth questions about the experiment.
3.4.5. Tasks

The participants are given no instructions other than to look at the monitor showing the stimuli. Duchowski (2007, 160) notes that gaze is both “bottom-up”, stimulus driven, as well as “top-down”, goal-oriented. Given that the study seeks to investigate the automatic gaze direction in different street types and are given no instruction, the thesis is heavily stimulus driven.
4. Results

Each image was analyzed using the following table that have been established with the help of our research framework. The visual attention was quantified in accordance to the description in the tables, as well as by color that corresponds to the heatmap, this is done for ease of understanding the image results.

If an element belonging to one of the four feature groups attract a specific amount of visual attention, then the cell will be colored with the specific visual attention color as seen in Table 4. The details of the coloring and to what element the visual attention is directed is described in text.

<table>
<thead>
<tr>
<th>Amount of visual attention</th>
<th>Very high</th>
<th>high</th>
<th>medium</th>
<th>low</th>
<th>none</th>
</tr>
</thead>
</table>

Table 4. Coloration used to color the different cells according to how much visual attention the feature and its elements attracts.

High visual attention represents long gaze time and strong correlation of visual attention between the participants. Also, the concentration of visual attention, and not just the intensity, is taken into account.

Figure 25. Visual attention focus point. When subjects focuses on one specific Spot the specific spot gets a warmer color.

Figure 26. Visual attention concentration. When subjects focuses on many areas of the image, no specific spot is focused on, but one can identify a larger general area of interest.
4.1. Blocked street type

<table>
<thead>
<tr>
<th>Features</th>
<th>Figure image result</th>
<th>Photo image result</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mass relations</strong></td>
<td>A very high amount of visual attention is directed to the height difference. Moderate amount of attention is directed to the right and left turns.</td>
<td>The right street turn draws low to no visual attention to itself, whereas the left turn draws a low amount of visual attention to itself - possibly due to a human standing in the turn.</td>
</tr>
<tr>
<td><strong>Fixed features</strong></td>
<td>High visual attention is directed at the roof of the terminating solid. Moderate to high amount of visual attention is given to the terminating solid. Barely any visual attention is directed to the rest of the solid facades. Most of the visual attention is concentrated on the terminating building.</td>
<td>The terminating solid attracts a very high visual attention. Barely any attention is given to the other surrounding solids.</td>
</tr>
<tr>
<td><strong>Semi-fixed features</strong></td>
<td>A device above the entrance, a street sign, and a railing outside an entrance draw a low amount of visual attention to themselves.</td>
<td></td>
</tr>
<tr>
<td><strong>Non-fixed features</strong></td>
<td>Humans in front of the terminating solid draws a low amount of visual attention to them.</td>
<td></td>
</tr>
</tbody>
</table>
### 2b. Horsstræde, Holsterbo, Denmark

<table>
<thead>
<tr>
<th>Features</th>
<th>Figure image result</th>
<th>Photo image result</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mass relations</strong></td>
<td>Very high visual attention is directed towards the left street turn, and high to medium visual attention is directed towards the right street turn.</td>
<td>Low visual attention is given to the left street turn, possibly due to the person standing close it. The right street turn attracts no visual attention.</td>
</tr>
<tr>
<td><strong>Fixed features</strong></td>
<td>The terminating solid attracts a high amount of visual attention and a large concentration of visual attention in general. The remaining solids mostly attract low amount of visual attention apart from one points on the right solids height differences that attracts medium amount of visual attention.</td>
<td>A very high amount of visual attention is directed towards the terminating solid. Only a small amount of visual attention is directed towards windows. The other solid facades receive low to no visual attention.</td>
</tr>
<tr>
<td><strong>Semi-fixed features</strong></td>
<td></td>
<td>Text and objects draws a low amount of visual attention to them, while one specific text on the right draws a medium amount of visual attention to itself.</td>
</tr>
<tr>
<td><strong>Non-fixed features</strong></td>
<td></td>
<td>A person standing at the left draws a medium amount of visual attention to itself.</td>
</tr>
<tr>
<td>Features</td>
<td>Figure image result</td>
<td>Photo image result</td>
</tr>
<tr>
<td>------------------</td>
<td>---------------------</td>
<td>--------------------</td>
</tr>
<tr>
<td><strong>Mass relations</strong></td>
<td>A very high amount of visual attention is directed to the left street turn. Medium visual attention is directed to the right street turn.</td>
<td>The right street turn attracts a high visual attention, whilst the left turn only attracts a medium amount of visual attention. Both of the street turns are likely influenced by the person at the left street turn and the sign on the right street turn.</td>
</tr>
<tr>
<td><strong>Fixed features</strong></td>
<td>Very high amount of visual attention is given to the terminating solid. The concentration of visual attention is directed to the terminating solid. Low or no visual attention is given to the rest of the solids.</td>
<td>A very high amount of visual attention is directed towards the terminating solid. The rest of the surrounding solids attracts low or no attention.</td>
</tr>
<tr>
<td><strong>Semi-fixed features</strong></td>
<td>A high amount of visual attention is given to the sign to the right, close to the terminating solid. Medium amount of visual attention is given to the sign on the right close to the camera.</td>
<td></td>
</tr>
<tr>
<td><strong>Non-fixed features</strong></td>
<td>Medium visual attention is given to the bike standing still in the left of the scene.</td>
<td></td>
</tr>
<tr>
<td>Features</td>
<td>Figure image result</td>
<td>Photo image result</td>
</tr>
<tr>
<td>-------------------</td>
<td>---------------------</td>
<td>-------------------</td>
</tr>
<tr>
<td><strong>Mass relations</strong></td>
<td>Two points where the sky meets the left solid attracts very high to low visual attention. The left street turn attracts low visual attention, whereas the right street turn attracts high visual attention.</td>
<td>The right street turn attracts a medium amount of visual attention, whereas the left street turn attracts low or no visual attention.</td>
</tr>
<tr>
<td><strong>Fixed features</strong></td>
<td>The terminating solid attracts very high visual attention. Most of the visual attention is directed to the terminating solid in general. The remaining solids attracts low or no visual attention.</td>
<td>The terminating solid attracts very high visual attention. The two remaining solids gets a medium amount of visual attention - most possibly due to the nearby signs, as the hotspots correlates with these. One window attracts low visual attention and the left door opening attracts medium visual attention.</td>
</tr>
<tr>
<td><strong>Semi-fixed features</strong></td>
<td>The sign to the immediate left attracts a high amount of visual attention. Two other signs attract medium visual attention.</td>
<td></td>
</tr>
<tr>
<td><strong>Non-fixed features</strong></td>
<td>The bike to the immediate right attracts low amount of visual attention.</td>
<td></td>
</tr>
<tr>
<td>Features</td>
<td>Figure image result</td>
<td>Photo image result</td>
</tr>
<tr>
<td>------------------</td>
<td>--------------------------------------------------------------------------------------</td>
<td>-----------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>Mass relations</strong></td>
<td>Low visual attention is given to both street turns and height differences.</td>
<td>High visual attention is given to the left street turn, this could however be influenced by the parked bikes. Medium visual attention is given to the change in building height. Low or no visual attention is given to the right street turn.</td>
</tr>
<tr>
<td><strong>Fixed features</strong></td>
<td>Very high amount of visual attention is given to the terminating solid. A large concentration of visual attention is directed to the terminating solid. Low or no visual attention is given to the other solids.</td>
<td>Very high amount of visual attention is given to the terminating solids. Medium visual attention is given to the store window containing items.</td>
</tr>
<tr>
<td><strong>Semi-fixed features</strong></td>
<td></td>
<td>Signage elements attracts a medium amount of visual attention on the right and left solids.</td>
</tr>
<tr>
<td><strong>Non-fixed features</strong></td>
<td></td>
<td>The parked bikes to the left of the terminating building draws a high amount of visual attention.</td>
</tr>
</tbody>
</table>
4.2. Open street type

<table>
<thead>
<tr>
<th>Features</th>
<th>1o. Drottninggatan, Gothenburg, Sweden</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mass relations</strong></td>
<td>Very high amount of visual attention is directed towards the terminating street. Low visual attention is given to the height difference in the distance.</td>
</tr>
<tr>
<td><strong>Fixed features</strong></td>
<td>Low or no visual attention is given to the surrounding solids.</td>
</tr>
<tr>
<td><strong>Semi-fixed features</strong></td>
<td>Low or no visual attention is given to semi-fixed features.</td>
</tr>
<tr>
<td><strong>Non-fixed features</strong></td>
<td>No existing non-fixed features.</td>
</tr>
</tbody>
</table>
### 20. Drottninggatan, Norrköping, Sweden

<table>
<thead>
<tr>
<th>Features</th>
<th>Figure image result</th>
<th>Photo image result</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mass relations</strong></td>
<td>A very high amount of visual attention is directed towards the terminating point.</td>
<td>A very high amount of visual attention is directed towards the terminating point.</td>
</tr>
<tr>
<td><strong>Fixed features</strong></td>
<td>High visual attention is given to the far away left solid. Medium visual attention is directed towards the far away right solid. Low or no visual attention is given to the remaining surrounding buildings.</td>
<td>High amount of visual attention is given to the far away right solid. High visual attention is given to the far away building to the left. Low or no visual attention is given to the other surrounding buildings. Low or no visual attention is directed to windows.</td>
</tr>
<tr>
<td><strong>Semi-fixed features</strong></td>
<td></td>
<td>Medium visual attention is given to the text close to the right solid above the display window.</td>
</tr>
<tr>
<td><strong>Non-fixed features</strong></td>
<td></td>
<td>Low visual attention is given to walking people, mostly the one on the right facing the subject.</td>
</tr>
<tr>
<td>Features</td>
<td>Figure image result</td>
<td>Photo image result</td>
</tr>
<tr>
<td>---------------------</td>
<td>-------------------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>Mass relations</strong></td>
<td>Very high visual attention is directed to the terminating point. Low or no visual attention is directed towards the height differences.</td>
<td>Very high visual attention is directed to the terminating point. Low or no visual attention is directed towards the height differences.</td>
</tr>
<tr>
<td><strong>Fixed features</strong></td>
<td>High amount of visual attention is directed to the far-away right solid. Low or no visual attention is directed towards the surrounding solid.</td>
<td>Low or no visual attention is directed towards the surrounding solid.</td>
</tr>
<tr>
<td><strong>Semi-fixed features</strong></td>
<td></td>
<td>No visual attention is directed towards the greenery.</td>
</tr>
<tr>
<td><strong>Non-fixed features</strong></td>
<td></td>
<td>Medium visual attention is directed towards a person to the right, apparently performing an action. Low visual attention is directed towards the parked bike close by.</td>
</tr>
<tr>
<td>Features</td>
<td>Figure image result</td>
<td>Photo image result</td>
</tr>
<tr>
<td>-------------------</td>
<td>-------------------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Mass relations</td>
<td><strong>Very high visual attention is directed to the terminating point. Low or no visual attention is directed towards the height differences.</strong></td>
<td><strong>Very high visual attention is directed to the terminating point. Low or no visual attention is directed towards the height differences.</strong></td>
</tr>
<tr>
<td>Fixed features</td>
<td><strong>Low or no visual attention is directed towards the surrounding solids.</strong></td>
<td><strong>Very high visual attention is directed to the far-away left solid. Low or no visual attention is directed towards the other surrounding solids.</strong></td>
</tr>
<tr>
<td>Semi-fixed features</td>
<td></td>
<td><strong>Medium visual attention is directed towards the text on the left. Low visual attention is directed towards the hanging flags.</strong></td>
</tr>
<tr>
<td>Non-fixed features</td>
<td></td>
<td><strong>Low visual attention is directed towards the parked bike.</strong></td>
</tr>
</tbody>
</table>

40. Mellbygatan, Lidköping, Sweden
# 50. Norrgatan, Växjö, Sweden

<table>
<thead>
<tr>
<th>Features</th>
<th>Figure image result</th>
<th>Photo image result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass relations</td>
<td>Very high visual attention is directed to the terminating point. Low or no visual attention is directed towards the height differences.</td>
<td>Very high visual attention is directed to the terminating point. Low or no visual attention is directed towards the height differences.</td>
</tr>
<tr>
<td>Fixed features</td>
<td>The far left solids’ roof attracts medium amount of visual attention. Low or no visual attention is given to the rest of the surrounding solid.</td>
<td>Low or no visual attention is given to the surrounding solids.</td>
</tr>
<tr>
<td>Semi-fixed features</td>
<td></td>
<td>Medium or low visual attention is directed to the surrounding signage elements.</td>
</tr>
<tr>
<td>Non-fixed features</td>
<td></td>
<td>Low visual attention is directed to the parked bike and cars.</td>
</tr>
</tbody>
</table>
4.3. Curved street type

<table>
<thead>
<tr>
<th>Features</th>
<th>Figure image result</th>
<th>Photo image result</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mass relations</strong></td>
<td>Very high amount of visual attention is directed to the terminating point.</td>
<td>Medium amount of visual attention is directed to the terminating point.</td>
</tr>
<tr>
<td><strong>Fixed features</strong></td>
<td>Very high amount of visual attention is directed to the far-away concave solid facade. High visual attention is directed towards the roof of the far-away concave solid. Low or no visual attention is directed toward the remaining surrounding solids.</td>
<td>Very high amount of visual attention is directed to the far-away concave solid facade. Low or no visual attention is directed toward the remaining solids.</td>
</tr>
<tr>
<td><strong>Semi-fixed features</strong></td>
<td>Medium to low visual attention is given to signage.</td>
<td></td>
</tr>
<tr>
<td><strong>Non-fixed features</strong></td>
<td>No non-fixed features present.</td>
<td></td>
</tr>
</tbody>
</table>
### 2c. Magstræde, Copenhagen, Denmark

<table>
<thead>
<tr>
<th>Features</th>
<th>Figure image result</th>
<th>Photo image result</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mass relations</strong></td>
<td>Very high visual attention is directed towards the terminating point. Low or no visual attention is directed towards the solid height differences.</td>
<td>Very high visual attention is directed towards the terminating point. Low or no visual attention is directed towards the solid height differences.</td>
</tr>
<tr>
<td><strong>Fixed features</strong></td>
<td>High visual attention is directed towards the far-away concave solid facade. Low or no visual attention is directed to the remaining surrounding solids.</td>
<td>Very high visual attention is directed to the far-away concave solid facade. Medium visual attention is directed towards parts of the far-away convex solid facade, possibly under influence of a signage element. Low or no visual attention is directed towards the rest of the solids.</td>
</tr>
<tr>
<td><strong>Semi-fixed features</strong></td>
<td>Medium visual attention is directed towards the left signage element. Medium or low visual attention is directed towards the remaining signage.</td>
<td></td>
</tr>
<tr>
<td><strong>Non-fixed features</strong></td>
<td>Low visual attention is directed to the parked bikes.</td>
<td></td>
</tr>
</tbody>
</table>
### 3c. Snaregade, Copenhagen, Denmark

<table>
<thead>
<tr>
<th>Features</th>
<th>Figure image result</th>
<th>Photo image result</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mass relations</strong></td>
<td>Very high visual attention is directed towards the terminating point. Low visual attention is directed to the height differences on the convex solid.</td>
<td>Very high visual attention is directed towards the terminating point. Low visual attention is directed towards the far-away concave roofs. No visual attention is directed towards the height differences.</td>
</tr>
<tr>
<td><strong>Fixed features</strong></td>
<td>Low visual attention is directed to both the far-away convex and concave solid facades.</td>
<td>Very high visual attention is directed towards the terminating buildings and the ones closest to them along the concave solid. Low or no visual attention is given to the remaining surrounding solid. No visual attention is directed towards the greenery.</td>
</tr>
<tr>
<td><strong>Semi-fixed features</strong></td>
<td></td>
<td>Medium to low visual attention is directed towards the signage.</td>
</tr>
<tr>
<td><strong>Non-fixed features</strong></td>
<td></td>
<td>Low visual attention is directed towards the parked bikes and cars.</td>
</tr>
</tbody>
</table>
### 4c. Torvegade, Vejle, Denmark

<table>
<thead>
<tr>
<th>Features</th>
<th>Figure image result</th>
<th>Photo image result</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mass relations</strong></td>
<td>Very high visual attention is directed towards the terminating point. Medium visual attention is directed towards height differences.</td>
<td>Very high visual attention is directed towards the terminating point. Low visual attention is directed towards the height differences.</td>
</tr>
<tr>
<td><strong>Fixed features</strong></td>
<td>High to medium visual attention is directed towards the far-away concave solid facades.</td>
<td>Very high visual attention is directed towards the far-away concave solid facade. Low visual attention is directed to the far-away convex solid facade. Windows and their containing items attract low visual attention.</td>
</tr>
<tr>
<td><strong>Semi-fixed features</strong></td>
<td></td>
<td>Medium to low visual attention is directed towards signage</td>
</tr>
<tr>
<td><strong>Non-fixed features</strong></td>
<td></td>
<td>No visual attention is directed towards non-fixed features.</td>
</tr>
</tbody>
</table>
### 5c. Vestergade, Varde, Denmark

<table>
<thead>
<tr>
<th>Features</th>
<th>Figure image result</th>
<th>Photo image result</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mass relations</strong></td>
<td>Very high visual attention is directed towards the terminating point. Low or no visual attention is directed to height differences.</td>
<td>Very high visual attention is directed to the height differences between the two furthest solids. High visual attention is directed towards the terminating point.</td>
</tr>
<tr>
<td><strong>Fixed features</strong></td>
<td>High visual attention is directed towards the far-away concave solid facade. The remaining solids attract low or no visual attention.</td>
<td>High visual attention is directed towards the convex solid close to the terminating point. This correlates with a signage element on said solid facade. The furthest solid facade on the concave solid attracts high to medium amount of visual attention in a concentrated area. The remaining solids attracts low to no visual attention. Some windows attracts a low amount of visual attention.</td>
</tr>
<tr>
<td><strong>Semi-fixed features</strong></td>
<td></td>
<td>A signage element on the far-away convex solid facade attracts high visual attention. A sign on the ground and the traffic light attracts low amount of visual attention.</td>
</tr>
<tr>
<td><strong>Non-fixed features</strong></td>
<td></td>
<td>No non-fixed features.</td>
</tr>
</tbody>
</table>
### 4.4. Angled street type

<table>
<thead>
<tr>
<th>Features</th>
<th>Figure image result</th>
<th>Photo image result</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mass relations</strong></td>
<td>Very high visual attention is directed towards the exterior street turn. Medium visual attention is directed towards both the exterior and interior street turn. Low visual attention is directed towards the left height difference.</td>
<td>Medium visual attention is directed towards both the exterior and interior street turn. Low visual attention is directed towards the left height difference.</td>
</tr>
<tr>
<td><strong>Fixed features</strong></td>
<td>Medium visual attention is directed towards the terminating building roof and lower facade. The remaining solids attracts low or no visual attention.</td>
<td>Medium visual attention is directed to the bottom floor windows of the terminating solid. Low visual attention is directed to the rest of the solids.</td>
</tr>
<tr>
<td><strong>Semi-fixed features</strong></td>
<td>The middle sign attracts very high amount of visual attention. The left sign on the left solid attracts medium amount of visual attention.</td>
<td></td>
</tr>
<tr>
<td><strong>Non-fixed features</strong></td>
<td>No visual attention is directed to the people.</td>
<td></td>
</tr>
</tbody>
</table>
### 2a. Kattesundet, Rønne, Denmark

<table>
<thead>
<tr>
<th>Features</th>
<th>Figure image result</th>
<th>Photo image result</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mass relations</strong></td>
<td>Very high visual attention is directed to the exterior street turn. Medium visual attention is directed to the interior street turn. Low visual attention is directed towards the height differences.</td>
<td>Very high visual attention is directed to the exterior street turn. Medium visual attention is directed to the interior street turn. Low visual attention is directed to height differences on the left solid.</td>
</tr>
<tr>
<td><strong>Fixed features</strong></td>
<td>Medium to low visual attention is directed toward the terminating solid. The remaining solids attract no visual attention.</td>
<td>Very high visual attention is directed to the terminating solid. Medium to low visual attention is directed toward windows and doors. The remaining solids attract low or no visual attention.</td>
</tr>
<tr>
<td><strong>Semi-fixed features</strong></td>
<td></td>
<td>Low visual attention is directed to an antenna.</td>
</tr>
<tr>
<td><strong>Non-fixed features</strong></td>
<td></td>
<td>No non-fixed features.</td>
</tr>
</tbody>
</table>
### 3a. Rosengården, Copenhagen, Denmark

<table>
<thead>
<tr>
<th>Features</th>
<th>Figure image result</th>
<th>Photo image result</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mass relations</strong></td>
<td>High visual attention is directed to the interior street turn. The exterior street turn attracts high amount of visual attention as well. Low visual attention is directed towards solid height differences.</td>
<td>The exterior street turn attracts a high amount of visual attention. Low amount of visual attention is directed to the interior street turn. Medium amount of visual attention is directed to the secondary mass height differences on the roof of the terminating building.</td>
</tr>
<tr>
<td><strong>Fixed features</strong></td>
<td>Very high visual attention is directed to the roof of the terminating solid close to the exterior street turn. Medium visual attention is directed to the left-side roof of the terminating solid. Most of the visual attention is concentrated on the terminating building, and towards the exterior street turn. The remaining solids draws low or no visual attention.</td>
<td>Very high amount of visual attention is directed to the terminating solid facade. Low to no visual attention is directed to the remaining solid facades and windows. Most of the visual attention is concentrated on the terminating solid.</td>
</tr>
<tr>
<td><strong>Semi-fixed features</strong></td>
<td></td>
<td>Low amount of visual attention is directed to signs, parked bikes and greenery.</td>
</tr>
<tr>
<td><strong>Non-fixed features</strong></td>
<td></td>
<td>Low amount of visual attention is directed to the people facing away from the subject.</td>
</tr>
</tbody>
</table>
### 4a. Salviigränd, Stockholm, Sweden

<table>
<thead>
<tr>
<th>Features</th>
<th>Figure image result</th>
<th>Photo image result</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mass relations</strong></td>
<td><img src="https://via.placeholder.com/150" alt="Image" /></td>
<td><img src="https://via.placeholder.com/150" alt="Image" /></td>
</tr>
<tr>
<td><strong>Fixed features</strong></td>
<td>Very high visual attention is directed towards the terminating solid left facade close to the exterior street turn. Low or no visual attention is directed towards the rest of the solids.</td>
<td>Very high amount of visual attention is directed to the exterior street turn. Low visual attention is directed to the interior street turn. Low amount of visual attention is directed towards building height differences.</td>
</tr>
<tr>
<td><strong>Semi-fixed features</strong></td>
<td>Low to no visual attention is directed to signs and lamps.</td>
<td></td>
</tr>
<tr>
<td><strong>Non-fixed features</strong></td>
<td>Low visual attention is directed to the people in front of the terminating solid.</td>
<td></td>
</tr>
</tbody>
</table>
### 5a. Østergravensgade, Aalborg, Denmark

<table>
<thead>
<tr>
<th>Features</th>
<th>Figure image result</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mass relations</strong></td>
<td>High amount of visual attention is directed towards the exterior street turn. Low or no visual attention is directed towards the interior street turn. High amount of visual attention is directed towards the height differences.</td>
</tr>
<tr>
<td><strong>Fixed features</strong></td>
<td>Very high visual attention is directed towards the terminating solid’s center as well as the part closest to the exterior street turn. High amount of visual attention is directed towards the roof. Low or no visual attention is directed towards the remaining solids.</td>
</tr>
<tr>
<td><strong>Semi-fixed features</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Non-fixed features</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Photo image result</strong></td>
<td>High amount of visual attention is directed to the exterior street turn. Low visual attention is directed to the interior street turn. High visual attention is directed to the height difference between the two parts of the terminating solid.</td>
</tr>
<tr>
<td><strong>Non-fixed features</strong></td>
<td>Low visual attention is directed towards the parked bikes.</td>
</tr>
</tbody>
</table>

Medium amount of visual attention is directed towards signs and lamps.
5. Discussion

In this chapter the results are analyzed and discussed. In order to make any conclusions about the thesis’ first question, *Is it possible to predict human visual attention in an urban environment based on the spatial arrangement reflected in a two-dimensional plan?*, the common or differing results from the figure images and photo images are of central concern for this discussion.

In order to answer the second question, *How can this predictive ability help planners and decision makers?*, the discussion will also encompass a comparison between the results of the different street types. This is done in order to find differences between the different street types. If such differences are found it would mean that planners can not only predict the visual attention from figure images, but it could also indicate whether there are any inherent patterns of visual attention in certain street types. If there are inherent patterns of visual attention tied to certain street types, then this could provide an improved understanding for the urban environment in the planning process.

The discussion will be centered on comparisons between visual attention of the figure image and its respective photo image. The discussion will also be centered on the comparison between the distribution of visual attention as it appears in different street types. Each street type is discussed and analyzed separately with basis in the background presented earlier in this thesis.
5.1. Blocked street type

Figure image 1b showcases that the higher amount of visual attention is directed to the contrasting height difference situated on top of the left solid. The rest of the visual attention is concentrated on the terminating solid facade as well as on both of the street turns. Both street turns are given the same amount of attention by the perceivers. The respective 1b photo image only showcases one of these patterns. Low or no visual attention is given to the contrasting height difference and hardly any to either of the street turns. The visual attention is instead concentrated to the terminating solid facade. The same pattern arises in figure and photo images 2b. While, in the figure image, there are no contrasting height differences to take into account, the visual attention is concentrated to the terminating solid and to both the right and the left turn. The respective 2b photo image only showcases how the visual attention is directed to the terminating solid facade, and neither street turn is given much attention. Blocked street image 3b differs slightly from these two earlier results. The figure image in this set of images attracts most of its visual attention to both street turns and a general concentration of visual attention is directed at the terminating solid, much like the other two previous figure images. The photo image do also show the same result as the two earlier photo images in the sense that the visual attention is concentrated on the terminating solid. However, the visual attention is also directed to both street turns, unlike in photo image 1b and 2b. This difference in visual attention could however be attributed to the signage element close to the right street turn (Chang & Ching-Horng 2015, 16) as well as to the person on the left street turn (Gehl 2010, 52:64, Rapoport 1980, 268). If only the primary masses would to be taken into account, the results of the 3b photo image would likely not deviate from the two previous ones. In figure image 4b it is possible to yet again see the trend that the figure image do attract most of the visual attention in a concentration on the terminating solid. However, a large amount of visual attention is directed to the right street turn and comparatively less is directed to the left street turn. The 4b figure image also shows that a lot of visual attention is focused on the contrasting height difference on the left solid. The respective 4b photo image showcases the same results as the earlier three photo images, namely that the visual attention is mostly focused on the terminating solid facade, and not much attention is given to either street turn. However, a small amount of visual attention is in this case directed to the right street turn. No visual attention is directed to the contrasting height difference at was the case in figure image 4b. Figure image 5b differs from the other figure images in the sense that very little visual attention is given to the street turns. Instead, the visual attention is concentrated on the terminating solid and a small
amount of the contrasting height difference on the terminating solid. The visual attention in the 5b photo image corresponds very well with that of the figure image. Only signage elements and people seem to influence the visual attention in a way that is not in line with the figure image.

Based on these results it would seem that the predictive abilities of the figure image within the context of a blocked street are only valid when it comes to how the visual attention is concentrated on the terminating solid, as well as the fact that no visual attention is directed to either the left or the right solids. This find indicates that solid facade accessibility plays a decisive role in predicting the visual attention of the perceiver, and that the content of the facade is only as visually attractive as the overall accessibility allows it to be. This find supports the understanding of environmental perception as proposed by Salingaros (2014, 44). The figure images all show how the visual attention is also directed to either one or both of the street turns, which is not the case in the respective photo images. As explained in chapter 3.2, the figure images can only account for the primary masses. So, the difference between the figure image and the photo image is that the photo image also includes secondary masses, details and subdivisions as well as semi-fixed and non-fixed features.

Since the blocked street type is a highly accessible street type in terms of the terminating solid facade (Salingaros 2014, 44), it is likely that the remaining fixed feature elements, i.e. the contents of the terminating solid facade, influences the perceiver to the extent that the street turns becomes of secondary, or no, interest. The findings also shows how greenery is not attracting visual attention at all in the blocked street type. This could be an indication that greenery do not attract visual attention, even though it has been found that greenery have highly positive perceptual qualities (Purcell & Thorne 1976; Rapoport 1980, 257; Rollo & Barker 2013, 1). This would in turn serve as an indication that the conclusion made by Kim et al. (2013, 92) that appraisal factors, such as greenery, gives longer gaze fixation time, is not supported in this instance. It rather supports Nolands (2016, 86) conclusion that the relationship between point of gaze and landscape appraisal factors remains unclear.

Contrasting elements were in the background chapter suggested to attract visual attention based on previous eye tracking studies (Ma 2003, 375-376; Horsely 2014, 185) and appraisal factors (Heath et al. 2000). But due to the inconsistent amount of visual attention contrast actually attracts indicates that contrast is not a determining factor of the distribution of visual attention and is not a reliable factor to take into account when predicting the visual attention based on figure images. This being said however, if the contrasting element is in fact a signage element, then the visual attention is likely to be attracted to it, this would be in line with the findings of Chang & Ching-Horng (2015, 16).
5.2. Open street type

In all of the four figure images depicting the open street type the visual attention is focused on the terminating point of the street. Only small amounts of visual attention is in some instances directed to the very far-away portions of the left and right solids. Photo images 1o, 3o and 5o replicates the focus on the terminating point and correlates because of this with their respective figure images. The remaining photo images 2o and 4o showcases slightly altered focus in their visual attention in comparison to their respective figure images. Both of these two photo images have a slightly higher visual attention directed to the far-away solids, one is more directed to the left solids while the other is more directed to the right solid. Only signage, and to a lesser degree people, influences the visual attention in a significant way, however, in a way that does not compare to the focus that is on the terminating point.

The small amount of visual attention directed to the left and right solids could be explained by how inaccessible they are to the perceiver (Salingaros 2014, 44). It seems like the eyes are rather seeking out the furthest possible point in the image, paying little attention to the surrounding buildings. The same street type were depicted in the study conducted by Chang & Ching-Horng (2015, 16). Their findings that the vanishing or terminating point consistently attracted visual attention and is only overcome by signage elements is confirmed by the results in this experiment. Much like in the blocked street type the greenery elements did not attract any visual attention, which was assumed to be the case due to the positive appraisal factors associated with these elements (Purcell & Thorne 1976; Rapoport 1980, 257; Rollo & Barker 2013, 1). This would further support the notion that the relationship with appraisal factor and point of gaze have no consistent correlation. Much like in the blocked street type, in the open street type the relationship between the solids is the primary factor that determines the area where visual attention is directed at.
5.3. Curved street type

Curved street figure image 1c shows how a high amount of the visual attention is directed to the terminating point as well as on the far-away concave solid facades. The convex solid do not attract any visual attention. The respective 1c photo image shows a similar pattern. The visual attention is however more concentrated to the far-away concave solid facade and less, albeit still a comparatively large amount, is concentrated on the terminating point. Other than this difference, signage elements in the photo image attracts some visual attention. The 2c figure image presents a similar pattern to that of figure image 1c. The visual attention is directed to the terminating point as well as on the concave solid facade, although, to a lesser extent than that of figure image 1c. The corresponding photo image 2c replicates the pattern of its respective figure image. The visual attention is directed to the terminating point to a very high degree. The visual attention is to an equally large extent also directed at the far-away concave solid facade. Little to no visual attention is directed to the convex solid in either the figure image or the photo image. The photo image does however showcase that some visual attention is directed at two signage elements. The 3c figure image differs somewhat from the two previous figure images as 3c only seem showcase how the visual attention is directed at the terminating point, and not much is given to the far-away concave solid facade. The respective 3c photo image follows the patterns of the previous two photo images. The visual attention is directed at the terminating point as well as concentrated to the far-away concave solid facade. Again, there seem to be no visual attention directed to any other features other than to one signage element on the close-by concave solid. The visual attention in the 4c figure image has a focus point on the terminating point and a concentration of visual attention on the concave solid facade. It also shows how a small amount of concentration of visual attention is directed at a contrasting height difference in the image. The respective 4c photo image shows a similar pattern, but instead of one single focus point on the terminating point, the whole far-away concave solid facade, with the terminating point included, is given a large amount of visual attention. The contrasting height difference is given very little visual attention directed to it in comparison to that of the figure image. Apart from this difference, signage elements on both the convex and concave solid facades attracts a medium to low amount of visual attention. The 5c figure image shows, again, how the visual attention is directed at the terminating point, with a smaller concentration of visual attention directed at the far-away concave solid facade. No other elements or features captures the visual attention. In the corresponding 5c photo image
this pattern is reversed. Instead, the focus point of the visual attention is directed at the far-away concave solid facade, and the smaller concentration of visual attention is directed to the terminating point.

In all cases described above, the figure images shows how the visual attention is primarily focuses on the terminating point, as would be expected by earlier research on image stimuli using an eye tracking device (Chang & Ching-Horng 2015, 16). The far-away concave solid facade is also attracting visual attention, but to a lesser extent. This attraction to the concave facade and not to the other surrounding facades is explained by its accessibility, as described by Salingaros (2014, 44), which is higher than the other surrounding solids. The photo images shows two differing outcomes in comparison to the figure images. The first outcome shows how the amount of visual attention concentration is expanded so that equal amount of visual attention is directed to the far-away concave solid facade as is on the terminating point. The second outcome shows how the focus is reversed so that the majority of visual attention is instead directed to the concave solid facade, and a lesser amount of visual attention is directed at the terminating point. Much like what we saw in the comparison between the figure and photo images in the blocked street type, the accessibility of the facades do seem to play a major role in how much visual attention they attract regardless of the content. However, if more content is given to the accessible facade, the facade seem to be able to override the visual attention that is given to the terminating point. In the curved street type we can see both how the concave solid facade overrides the terminating point, or is equal to the terminating point, in terms of how much visual attention it attracts. The contrasting height differences appear to attract inconsistent amount of visual attention throughout the stimuli, and even though being suggested to attract visual attention due to appraisal factors (Ma 2003, 375-376; Heath et al. 2000; Horsely 2014, 185) appears to not play a decisive role in the distribution of visual attention in the curved street type.

5.4. Angled street type

The 1a figure image showcases four areas that the visual attention is attracted to. One of these area is more prevalent than others as it takes the form of a focus point directed at the exterior street turn. The second, lesser focus point, is directed to the opposite street turn, the interior street turn. There is also a concentration of visual attention on the terminating solid itself as well as on the roof of this solid. The 1a photo image does not replicate this pattern. It seems like both of the street turns attracts an equal and low amount of visual attention, and
instead, the majority of the visual attention is focused on the signage elements on the terminating solid facade. It seems as though the contrasting signage element overrides the image’s other elements to the extent that the form of the street or buildings were less interesting to the perceivers. Examples of this were also found in the study made by Chang & Ching-Horng (2015, 16). The signage element in this particular image attracts comparatively more visual attention than the previous signage elements did throughout this experiment. It is likely that the combination of the signage element being on the accessible terminating solid facade (Salingaros 2014, 44), being a signage element (Chang & Ching-Horng 2015, 16) as well as contrasting from its environment (Ma 2003, 375-376, Horsley 2014, 185) resulted in optimal conditions for it to pull visual attraction unto itself. Thus, unfortunately due to this combination the 1a figure image was not able to predict the distribution of visual attention on the respective photo image. The 2a figure image is showing the same patterns as the 1a figure image. The focus point is directed at the exterior street turn, with a small extension of the visual attention extending to the terminating solid facade. A lesser amount of visual attention is directed to the interior street turn. The 2a photo image adopts this pattern as well, albeit with the visual attention more evenly distributed on the stimuli. The majority of the visual attention is directed to the exterior street turn and on the terminating solid facade. The interior street turn receives comparatively little visual attention. Even though the visual attention is somewhat differently distributed between the 2a figure image and photo image, the 2a figure image do predict a large amount of visual attention directed towards the exterior street turn, and this prediction is fulfilled in the photo image. The results of the 3a figure image indicates that there is also a large amount of visual attention directed towards the exterior street turn. There are three focus points on the figure image, one of which is on the terminating solid facade, the other on the exterior street turn and the third and least prominent on the interior street turn. The three focus points belongs to the same concentration of visual attention directed at the entirety of the terminating building facade. The respective photo image replicates this pattern, but with stronger emphasis on the bottom half of the terminating solid facade. There is also a contrasting roof element on top of the terminating solid that attracts some visual attention. Smaller signage elements on the right and left solids receives only a small amount of visual attention. In figure image 4a we can again see how the majority of the visual attention is directed at the exterior street turn as well as to the terminating solid facade immediately close to this turn, while the opposite street turn receives a comparatively small amount of visual attention. Much like the last 3a photo image the 4a photo image showcases a similar pattern to its corresponding figure image. The emphasis is on the exterior street turn as well as on the terminating solid in the direction of this turn. The opposite turn is again receiving less visual attention. In figure image 5a the emphasis on exterior street turn, as well as the terminating building close to said street turn, is even greater than that of the previous angled streets. The same emphasis can be found in the respective 5a photo image.

The figure images all seem to attract the visual attention to the terminating buildings’ facade and four out of five figure images attract visual attention to the exterior street turn. The part of the terminating solid that attracts the most visual attention is the one close to the exterior street turn. Once again, we have demonstrated the decisiveness of the accessibility of the solid facades and how they together with the terminating point are the most reliable
elements with which one can predict visual attention. This notion is supported by both
(Salingaros 2014, 44) as well as that of Chang & Ching-Horng (2015, 16). Visual attention
directed to height difference contrasts remains inconsistent also in this street type, despite
the effect it has had in previous studies (Ma 2003, 375-376; Heath et al. 2000; Horsely 2014,
185). This deviation could possibly exist due to the content of the stimuli, the prominence of
the contrasts as well as the time that the subjects spent perceiving the stimuli. We can also
see how the greenery elements are not attracting any visual attention, thus supporting the
findings in the other four street types, despite greenery having positive perceptual qualities
(Purcell & Thorne 1976; Rapoport 1980, 257; Rollo & Barker 2013, 1).

In summary, simple figure images that can be created based on a detailed development plan
do have an ability to predict the visual attention of the realized product. Causes of
divergence from the figure image prediction seem to be affected mostly by semi-fixed
signage elements. The other semi-fixed features that were assumed to be prominent in how
they attracted visual attention were the green elements. However, it seem like greenery did
not attract any visual attention. The facade texture and openings seem to influence the visual
attention in an inconsistent way and to an otherwise low degree. The difference in height
between primary masses seem to garner low or no visual attention. The addition of people
on the photo image seem to have no effect on the visual attention unless the people are
directly facing the subject. This discussion has however shown that primary masses and the
relation between them are the most powerful determining factors for visual attention.
Indeed, they seem to be more powerful than the actual design or content of building facades
or the other content of the streetscape - with the exception of signage elements, which seem
to be able to override all other elements in the streetscape. Table 5 below summarizes this
discussion.

<table>
<thead>
<tr>
<th>Streetscape features</th>
<th>Present in figure image?</th>
<th>Impact</th>
<th>Effect on predictability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass relations</td>
<td>YES</td>
<td>High</td>
<td>Increased</td>
</tr>
<tr>
<td>Fixed features</td>
<td>BOTH</td>
<td>BOTH</td>
<td>Increased</td>
</tr>
<tr>
<td></td>
<td>Primary and secondary</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>masses are present.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Details and subdivisions</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>are not.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Semi-fixed features</td>
<td>NO</td>
<td>YES</td>
<td>Decreased</td>
</tr>
<tr>
<td></td>
<td>Only signage elements</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>have high impact, not</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>greenery.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-fixed features</td>
<td>NO</td>
<td>NO</td>
<td>Increased</td>
</tr>
<tr>
<td></td>
<td>Inconsistent and</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>generally low impact.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 5. The above table summarizes the content of the discussion.
6. Conclusion

In this chapter the two questions posed by the thesis will be answered based on the discussion in the previous chapter.

6.1. Is it possible to predict human visual attention in an urban environment based on the spatial arrangement reflected in a two-dimensional plan?

The figure image for the open, curved and angled street types seem to offer a consistently good prediction on how people's visual attention is distributed on the corresponding photo image. The only thing the figure image could not predict, that constituted the differing visual attention in the photo image, were semi-fixed sign elements and non-fixed human elements. In contrast to the conclusion about the above mentioned street types, the figure image had a harder time predicting visual attention when it depicted a blocked street type. The figure images generally attracted more attention to either of the street turns, while the photo images attracted most of the visual attention to the facade of the terminating solid. The individual details of the building masses therefore might play a bigger role in the blocked street type, than in other types of streets, since they seem to have a bigger effect on the visual attention of the perceiver. This indicates that the more accessible the facades are to the perceiver, the more the content of the facades determines how visual attention will be distributed. However, it seems that the content of the accessible solid do not have to be particularly elaborate in order to attract the visual attention. The contents of the facades on inaccessible solids seem to not matter at all since no visual attention is directed to the inaccessible solids regardless of the street type being represented as a figure or photographic image.

There seemed to be a general inconsistency in the prediction of visual attention directed towards building height differences. Sometimes visual attention was directed to height differences in the photo image, but not in the figure image, or vice versa. However, in general, contrasting heights did not attract much, if any, visual attention. The figure images could thus be unreliable in how they predict visual attention directed towards height differences. Furthermore, neither greenery nor human activity seem to influence the visual attention in any consistent ways.

To conclude, figure images, that can be created based on two-dimensional maps, do have an ability to predict where the general visual attention will be directed in the realized product. This seem to largely be due to of how prevalent the role of street types is for the visual attention of the perceiver. Only signage elements overrides the attraction of visual attention that is otherwise controlled by the street type.
6.2. How can this predictive ability help planners and decision makers?

The results do not just show what elements can be assumed to be more or less reliable when predicting the visual attention based on a figure image, but they also show that the different street types have inherent patterns of visual attention. These patterns can be utilized by planners or decision-makers as general rules of thumb, without the planners having to conduct separate eye tracking experiments on their figure image projects in order to predict the visual attention of their design.

From the discussion it is possible to find an inherent pattern of visual attention when people are subject to a blocked street type. This street type attracts a large amount of visual attention on the terminating building facade and hardly any visual attention is directed to either the street turns or the surrounding building facades. The visual attention is generally distributed on a large area on the terminating building.

Just like the blocked street type, the open street type also seem to have inherent effects on the visual attention of the subjects. The open street type focuses the visual attention to the street termination point, and in some cases the very far-away building facades. However, it appears that most of the building facades remain outside the point of gaze.

The curved street type attracts visual attention to the terminating point of the street as well as on the building facades along the far-away concave solids. The convex building facades and the close-by facades of the concave buildings attracts little to no visual attention.
The angled street type have a visual attention effect that is similar to the curved street type. The focus is on the exterior street turn, as well as on the part of the terminating solid facade closest to this street turn. The interior street turn and remaining part of the terminating building facade attracts comparatively less visual attention. The remaining solid facades attracts little to no visual attention.

All four different street types presented and investigated in this thesis have shown to induce inherent patterns on the distribution of visual attention of the perceiver. However, it is important to note that even though the street types have inherent effects on visual attention, other elements can override this effect. These elements are signage and to a lesser extent people. Moreover, even though the termination points and solid facades attracts visual attention based on the street type, the lesser elements on or around these inherent areas, such as windows or subdivisions, alters how the visual attention is distributed.

In conclusion, street types do play a decisive role in how people perceive the streetscape environment. This role seems to be even a bigger role than that of individual buildings. This puts an increased importance to the context of a building, rather than the building itself. The two-dimensional plan, which is the primary means of planning, do seem to have predictive abilities if developed into a simple figure image. The results in this thesis contributes to planners and decision makers ability to better predict the outcome of a design as early as in the planning stages.

Even though the criticism of the two-dimensional plan, as being disconnected from the realized product, might still be valid - the results in this thesis shows that it is possible to predict the distribution of visual attention and hence create a connection between the two-dimensional map and the three-dimensional world.
7. Further research and other indications

This thesis makes use of only a few of the possible factors that could have an impact on the visual attention of the participants. Other studies have explored factors such as mystery, tidiness and complexity. Given the result turnout for the blocked street type in this thesis, complexity seem to be a factor that influences the visual attention. However, the thesis did not take this into account and cannot therefore conclude anything from what effects it might have had on the results. The intricacy of primary masses, and lesser fixed features such as details, seemed to have an effect on the visual attention. The thesis did manage to frame building content complexity as being a possible factor influencing visual attention, provided a given building facade is accessible. This phenomenon should be investigated further in future eye tracking studies.

The thesis shows that the street type, or solid-void arrangements of the primary masses, is the biggest determinant for how people’s visual attention is distributed on the image. The only other element that seemed to override this effect in some instances where those of semi-fixed signage elements. However, some signs did a better job at overriding the effect of the street type than others. This might be due to sheer contrast. Further research could be done on signage design and placement in relation to the street type.

The results in this thesis supports the conclusion made by Badland et al. (2010) about google street view being a cost-effective stimuli alternative. The biggest drawback with google street view images are the street name texts that seem to be unremovable at the time when this thesis is written. However, it seemed that comparatively little or no visual attention was attracted to the street name text and it did not seem to disturb the results in a major way. Thus, google street view seem to be a viable source for cost-effective gathering of image stimuli.

It’s possible that the visual attention is focused elsewhere in a real life situation, for example it could be directed at your phone, items in store windows or on the ground in front of you. But even if the sight patterns discovered in this thesis were given only a few seconds of attention in a real life situation, it is possible that these patterns are the automated physiological sight patterns used to identify the spatial arrangements in the environment. It would therefore also be interesting to find whether it is a perceived quality to experiencing a variation of street types and sight patterns. If such a quality could be found it would provide supporting evidence for building cities and neighborhoods with more varying street types.

I also find it interesting to investigate an eventual connection between visual attention and memorability in a streetscape context. If such a connection could be found it would mean that streetscapes with mass arrangements that are favorable, in terms of their accessibility, would have a higher probability to be remembered by perceivers. This could in turn help explain why people choose to visit or romanticize certain areas, or whole cities, over others - simply because they are more memorable based on accessibility.
8. References


Purcell, A.T. & Thorne, R. (1976). *Space for Pedestrian Use in the City of Sydney*. University of Sydney, Department of Architecture, Architectural Psychology Research Unit.


Robinson, J. B. (1899). *Principles of architectural composition; an attempt to order and phrase ideas which have hitherto only been felt by the instinctive taste of designers*. The architectural record co, New York.


Appendices

Appendix 1. Slideshow order

<table>
<thead>
<tr>
<th>Slideshow 1</th>
<th>Slideshow 2</th>
<th>Slideshow 3</th>
<th>Slideshow 4</th>
<th>Slideshow 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>b1a</td>
<td>b2a</td>
<td>b3a</td>
<td>b4a</td>
<td>b5a</td>
</tr>
<tr>
<td>o1b</td>
<td>o2b</td>
<td>o3b</td>
<td>o4b</td>
<td>o5b</td>
</tr>
<tr>
<td>c1a</td>
<td>c2a</td>
<td>c3a</td>
<td>c4a</td>
<td>c5a</td>
</tr>
<tr>
<td>a1b</td>
<td>a2b</td>
<td>a3b</td>
<td>a4b</td>
<td>a5b</td>
</tr>
<tr>
<td>b1b</td>
<td>b2b</td>
<td>b3b</td>
<td>b4b</td>
<td>b5b</td>
</tr>
<tr>
<td>o1a</td>
<td>o2a</td>
<td>o3a</td>
<td>o4a</td>
<td>o5a</td>
</tr>
<tr>
<td>c1b</td>
<td>c2b</td>
<td>c3b</td>
<td>c4b</td>
<td>c5b</td>
</tr>
<tr>
<td>a1a</td>
<td>a2a</td>
<td>a3a</td>
<td>a4a</td>
<td>a5a</td>
</tr>
</tbody>
</table>

\[ b_{xx} = \text{Blocked street type} \quad x_{1x} = \text{Streetscape 1} \quad x_{xa} = \text{Photographic stimuli} \]
\[ a_{xx} = \text{Open street type} \quad x_{2x} = \text{Streetscape 2} \quad x_{xb} = \text{Figure stimuli} \]
\[ c_{xx} = \text{Curved street type} \quad x_{3x} = \text{Streetscape 3} \]
\[ a_{xx} = \text{Angled street type} \quad x_{4x} = \text{Streetscape 4} \]
\[ x_{5x} = \text{Streetscape 5} \]
Appendix 2. Form of consent
(also offered in swedish and arabic)

Eye-tracking Experiment - Consent Form

Experiment Purpose & Procedure
The purpose of this experiment is to investigate whether different street types elicit differences in visual attention.

In this experiment, you will watch a series of images on a monitor while the eye tracker records your eye movements. In total, 40 images will be presented, each for a duration of 10 seconds. After the presentation of each group of 10 images, the eye-tracking device will be recalibrated.

Confidentiality
The following data will be recorded: Eye movement, age, sex and ethnicity. All data will be stored anonymously. Thus no personally identifiable information can be associated with this study if its results were to be shared through presentations or publications.

Finding out about result
If interested, you can find out the result of the study by contacting the researcher Martin Månsson, after date 2017-07-07. His phone number is 0733741197 and his email address is MartinJanMansson@gmail.com.

Record of Consent
Your signature below indicates that you have understood the information about the eye-tracking experiment and consent to your participation. The participation is voluntary and you may withdraw from the study at any time, however, voluntary withdrawal results in no monetary compensation (0 kr). You should have received a copy of the consent form for your own record. If you have further questions related to this research, please contact the researcher.

<table>
<thead>
<tr>
<th>Participant</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Researcher</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>