Gendered Walkscapes

Eye-tracking as an innovative tool to analyse people's perception of urban spaces

MA4-URB10, June 2021

Luisa Vitolo

TITLE PAGE

Master Thesis´title:
Gendered Walkscapes:
Eye-tracking as an innovative tool to analyse people's perception of urban spaces

University:
Aalborg University

Degree:
Urban Architecture

Group/Name:
MA4-URB10, Luisa Vitolo

Supervisor:
Michael Martin

Master Thesis`Periode:
February 2021 - May 2021

Number of pages:
79

Luisa Vitolo

Acknowledgements

This semester started for me in an unusual and stressful way due to my request for the supervisor's replacement. I want to thank my supervisor Michael Martin for taking me in despite having a high number of students under his care and for his help requesting the eye tracker glasses to the University, which enabled me to test the technology which my dissertation is based upon.

This final phase is very important to me. It not only means the end of my master's program, but the culmination of two years of hard work. In itself it also is the last step on a personal journey that started ten years ago, when after studying in the University of Naples, I moved to Denmark to work.

I dedicate this dissertation to my children, Leonardo and Lorenzo. Their resilience through this process which entailed my mental and physical absence is greatly treasured.

I would also like to thank my husband Gerardo for always supporting me.

My two sisters, Antonella and Paola constantly sent me words of encouragement from Italy during this process, so I thank them dearly as well.

To all the participants in this project - Enzo, Ellen, Karina, Giulia, Alessia, Pietro, Luigi, Bettina and Gerardo: without you, this dissertation would not exist.

Lastly, thanks to Ciro for his critical point of view on my writing.

Abstract

An internationally accepted strategy to ensure gender equality is "Gender Mainstreaming". The main focus is to look at gender perspectives in all sectors, from political to city planning and monitoring. In the EU, a transparent action plan needs to be drawn according to the context. Vienna city has applied this strategy in its planning and has achieved several pilot projects considering gender needs in all planning phases.

Nowadays, technology plays a key role in every field and has become essential in everyday life. It also evolves at a fast pace. Eye-tracking technology is not the same as the one that existed some years ago, which used to be heavy and complicated to calibrate. Today it is smart and easy to use. Moreover, it is now utilized in many fields, including urban design.

The intention is to inquire into the human perspective on an in-depth study when it comes to urban experiences and to introduce gender-sensitive planning into the schema. This dissertation aims to test the eye-tracking method by means of experiments and propose new tools for registering, recording, and responding to potential built environment biases.

The literature review on the Eye-tracking method applied in the subject has shown the gap regarding gender comparison and the proper methodology to consider for data gathering. The experimental design method combined with surveys is used for this thesis.

The selected walking route in the Aalborg town center was analyzed through typical site analyses like the legibility map and serial vision, to deeper understand the study site. Then, in the experimental framework, the tests were carried out on nine participants. Pupil Invisible Glasses were involved as the technology for the method. Recorded data were processed through Pupil Player software. In the end, data analyses and surveys were compared and discussed between a segment of the adult and senior target group subdivided into male and female assemblies.

The process of doing the investigation has drawn itself essential tips for future application of the Eye-tracking method. It was strengthened that it is a method that can be applied in general, not only for the gender perspective`s inquiries. The careful definition of relevant research questions and surveys can make the specific case.

Keywords:

Gender-sensitive planning; *Eye-Tracking*; *Streetscape*; *Pedestrian perspective.*

Table of contents

List of figures

List of used software

Pupil Player

Pupil Capture

Elan

QGIS

AutoCad

Rhino

Adobe Illustrator

Adobe Photoshop

Adobe InDesign

Microsoft Excel

Microsoft Word

Google Forms

Pupil Invisible Eye-tracking Glasses on, Aalborg city

Introduction

The world population is increasing along with the number of people who live in cities. Concepts like sustainability and livability in such a scenario are becoming regular discussion points, centering around the importance of the role of people. The attention in urban cities revolves around taking care of dwellers' mental health and well-being.

The urban space is where people socialize, interact with others, feel relaxed or annoyed. It influences mental health, happiness, creativity, productivity, generosity and overall health. It is an environment made for them, so it becomes essential to investigate how they see and behave in it. Investigating the pedestrian perspective allows professionals to understand how an urban space influences the Persona on an unconscious level. It helps urban design projects and improvements become more workable and sustainable. That is why utilizing a smaller model of the city by investigating the pedestrian perspective and using new technologies becomes a powerful method.

When connected to visual attention, eye-tracking technology can become a tool to aid this method. It enables to get where the human eye`s attention and focus lie observing a scene (Duchowski, 2017). The basis for the technology is defined by eye movements. In the specific instance, the human eye inspects a given scene to watch in fast moves and low resolution (Duchowski, 2017). Afterwards, the eye takes into focus what the mind asks for attention. Therefore, tracing out eye movements allows gathering people`s points of attention when looking at images or, for example, at a streetscape or square in an urban environment.

Nowadays, there are two main types of eye-tracking on the market: Desktop and Mobile. The first one works linked to a computer with a specific gaming use (Tobii, 2021). The second one takes the form of glasses (AB, 2021) and is a very interesting tool for research. Because the new technologies can be used when walking around the town and looking at urban space like the ones made, for example, by companies like Tobii (AB, 2021) or Pupil Labs (GmbH, 2021), the pedestrian point of view and interest can be analyzed. New models are even more accurate and lighter than earlier ones. They are interactive, easy to calibrate and to manage the data collected by them.

These technologies based on videos, use cameras and computational elaboration of data-images (Duchowski, 2017).

The cornea and the pupil are the foundations for the human eye. Two cameras are installed on the eye-tracking glasses. The first one can catch the corneal reflections (Mitsugami, et al., 2005) by near-infrared light sent in the center of the pupil. The other one records the users' point of view in the real world. Finally, all the data is processed by mathematical algorithms. An important process step is the eye-tracking`s calibration since glasses need to know the exact pupil`s center to calculate the correct direction of the gaze (Duchowski, 2017).

A disadvantage of utilizing this technology could be

its high cost, especially when talking about the Tobii eye-tracking glasses (AB, 2021). This is owing to the specific software's cost to process the data. Another issue is that the overall sense of space is not given; only isolated images are returned. That is why other technologies, such as GPS-tracking, have to be put together for the investigation to be effective.

GPS stands for Global Positioning System. It allows gathering information about set positions on Earth precisely in times, intersecting a minimum of four distances between a GPS device and signals from one of the about 24 satellites (Office, n.d.). iPhones or smartwatches could be GPS devices, and Google Maps or TomTom could be the apps to use. Finally, outcome data containing linked time and space information are processed through software such as QGIS and displayed on maps.

The research question for this thesis is the following:

"Could the eye tracker be utilized to explore the gender perception of urban spaces, and consequentially, to better the city`s value?"

Topic: Human perspective and experience in living in the city.

Aim: This thesis aims to test the eye-tracking method by means of experiments and propose new tools for registering, recording, and responding to potential built environment biases.

Purpose: The purpose is to compare typical analysis methods with a new technological one, building on the concept of imageability by Kevin Lynch. Moreover, it wants to introduce gender-sensitive planning to the field.

Outputs: Give recommendations about using the method as a tool to help designers make and test their urban designs.

Theoretical framework

This chapter will build the foundations for the study. Basic theories will be discussed to understand the human eye and how it is involved in the Eye-tracking technology. Furthermore, the application of the method will be investigated through literature review and related gaps will be found. Finally, the introduction to gender-sensitive planning will be introduced to solve the gap regarding the missing comparison between demographic groups.

Eye-tracking technology

The eye-tracking technology enables the investigation of the people's point of view, going on a detailed city scale.

It works by analyzing where the human eye centers its points of attention in a given situation. That is why it is key to understand the mechanism of the human eye.

The first person that became interested in knowing how the human eye worked was Leonardo da Vinci. He found what is now regarded as basic knowledge, which is, that the eye sees the real picture reversed and then the brain adjusts it. Years later, building up from that, Kepler developed his studies about the vision. (Gross, 1997)

The human eye is essentially made up of a cornea, pupil, iris, lens, retina, fovea, and optic nerve. The cornea focuses the image, while the pupil measures the light, dilating or contracting itself together with the iris depending on the amount in the environment. Afterwards, the lens modifies the curvature of the image. Finally, the inverted image arrives at the retina, a membrane made up of rods and cones, which allows the picture to be seen clearly and to transform light stimuli into neural signals.

The fovea, derived from the Latin word for pit, is constituted of cones, and is situated at the center of the retina. It is the point where the distinct and central vision, called "*foveal vision*", happens. In the last stage, the neural signals, which have arrived in the optic nerve, are carried by neurons to the diencephalon. There, stimuli are allocated in different areas of the "*occipital cortex*," and the image is finally reassembled and defined. (Duchowski, 2017)

The image is not initially seen at a high resolution by the eye as a whole. Only parts of it will be taken by the foveal vision, which defines the points of attention (Duchowski, 2017). These, called "*points of fixation*", will be what the eye-tracking technology will look for.

Two main movements of the eye are essential for the technology to work: *fixations* and *saccades*. The former occurs when the eye has found the area or point of attention and focus on that. The latter refers to fast movements between fixations.

Through all of this process we can see that the eye is not perfect performing. Some defects, like "*Spherical and Chromatic aberrations*", and "*Curvature of field*", occur (Duchowski, 2017). However, it has developed the ability to compensate for those problems. Understanding the optical gaps allows eye-tracking technology to work accurately, fix the offsets and issue better results.

The eye-tracking technology, which is going to be used for the investigation, is video-based. This means that the technology uses cameras and computerized images to determine points of attention. Infra-red light is sent to the eye. Afterwards, the corneal or "*Purkinje*" reflections from it along with the pupil positions are recorded as images and processed through video frames (Duchowski, 2017).

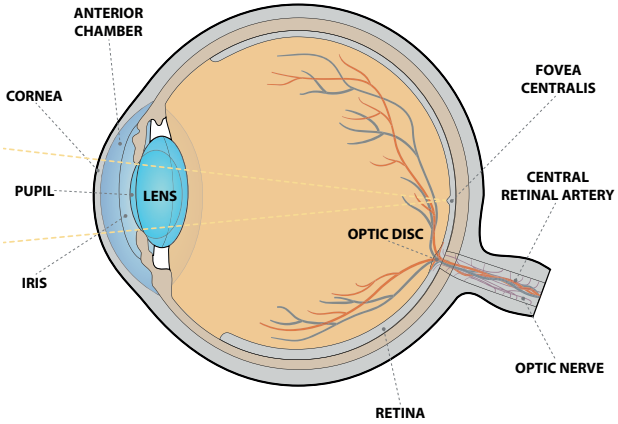


Figure 1: *The eye structure*

Figure 2: *How the Eye-tracking glasses work*

Visual imagery

Looking at a picture, a building, an urban space, or simply an object is more than just seeing it. The process involves the brain understanding it and connecting it to personal experiences, feelings, and emotions.

In his theory about "*visual mental imagery*" (Kosslyn, 2005), Stephen Kosslyn argues that six main elements can be involved in the process when input is given from the eye. The brain starts to set up information about the point of attention in the visual buffer, where the attention window constitutes a specific part of this element. These data can then go further through two brain lobes: spatial properties processing, which focuses on the position of something in the space, and object properties processing, where information about color, texture, and shape are processed. Then they run into associative memories, where more properties related to memory are potentially associated with the object. Finally, information shunting and attention shifting become the last components where the perception works. (Kosslyn, 2005)

In conclusion it can be said that the visual attention plays an important role in understanding people's perception and feeling of a place, streetscape, or landscape. Different attention points can be influenced by personal mental states and experiences, different genders, ages and professions, etcetera.

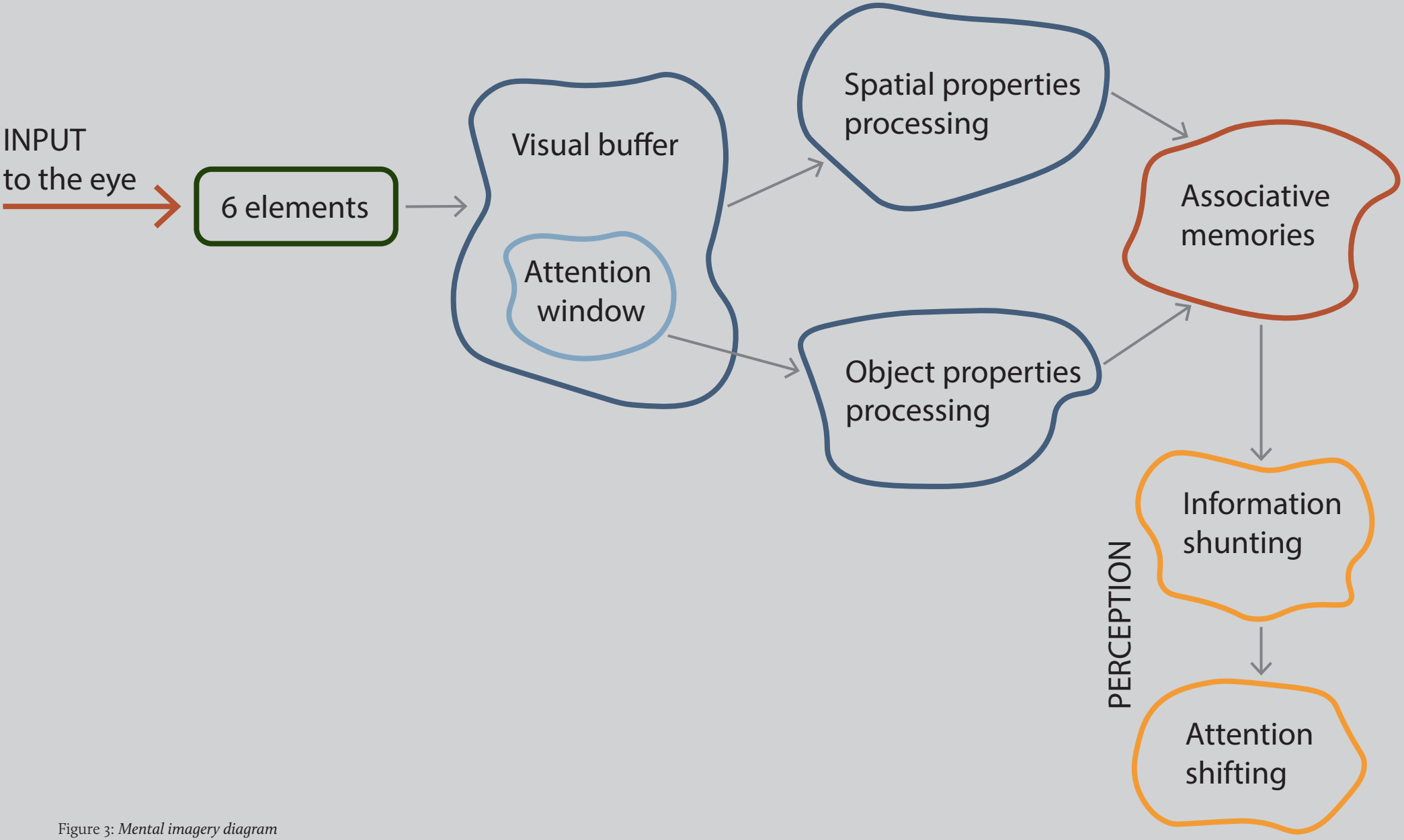


Figure 3: *Mental imagery diagram*

"Imageability" and "Serial Vision"

The eye-tracking method is a tool that can help us understand the pedestrian's visual focus in an urban environment. It allows us to do a "*perception analysis*" of a space by using new technology. However, if we categorize this as a new or supplementary way of analyzing the urban space, like this dissertation wants to propose, what happens to the common site-analysis techniques in terms of imageability of the space, like the theories of Kevin Lynch and Cullen? Can these be compared to this new way of exposing the human perspective? What is more, can the eye-tracking method overshadow these common ones?

In order to be able to answer these questions at on this dissertation, the concept of imageability by Kevin Lynch and the "Serial Vision" by Cullen need to be introduced.

Kevin Lynch talks about the concept of "*imageability*" in his book '*The Image of the City*' (Lynch, 1964), which is essential to the city's ability to create a vigorous image of it in the "*observer*". This process happens through a constant interchange of "*Identity*", "*Structure*", and "*Meaning*" between the urban environment and its observer. The latter "selects", "organizes" and "gives a meaning" to the five "elements" of the environment, which are: "*paths*", "*edges*", "*districts*", "*nodes*", and "*landmarks*" (Lynch, 1964).

It is interesting to point out that, according to Lynch, "*imageability*" can take other names, such as "legibility" and "visibility". When put together at the same time they convey the importance of seeing, interpreting or expressing the city. (Lynch, 1964)

Lynch gives importance to the use of the eye for involving observers in "attention and participation" and how that can create different images in them. This perception of the city is directly related to the visual perception for the Eye-Tracking method and underlines the importance of the detection of attention points in the urban space. In that way, these images made by participants can be compared to what they actually have seen through the individuation of fixation points.

An example of the theory of Imageability can be the Serial Vision Analysis conceived by the English urban planner Gordon Cullen. This analysis uses pictures from a human point of view angle to convey the visual experience of a site. (Cullen, 1971)

In his "*The Concise Townscape*" book, Gordon Cullen mentions that the scenes seen walking down a path change every time, even if the walking speed keeps steady (Cullen, 1971). The path is made up of serial images whose significance relies on how a space or street is perceived. That is why the combination between the human eye perception and the general feeling of a place have to be investigated to understand the environment. (Cullen, 1971)

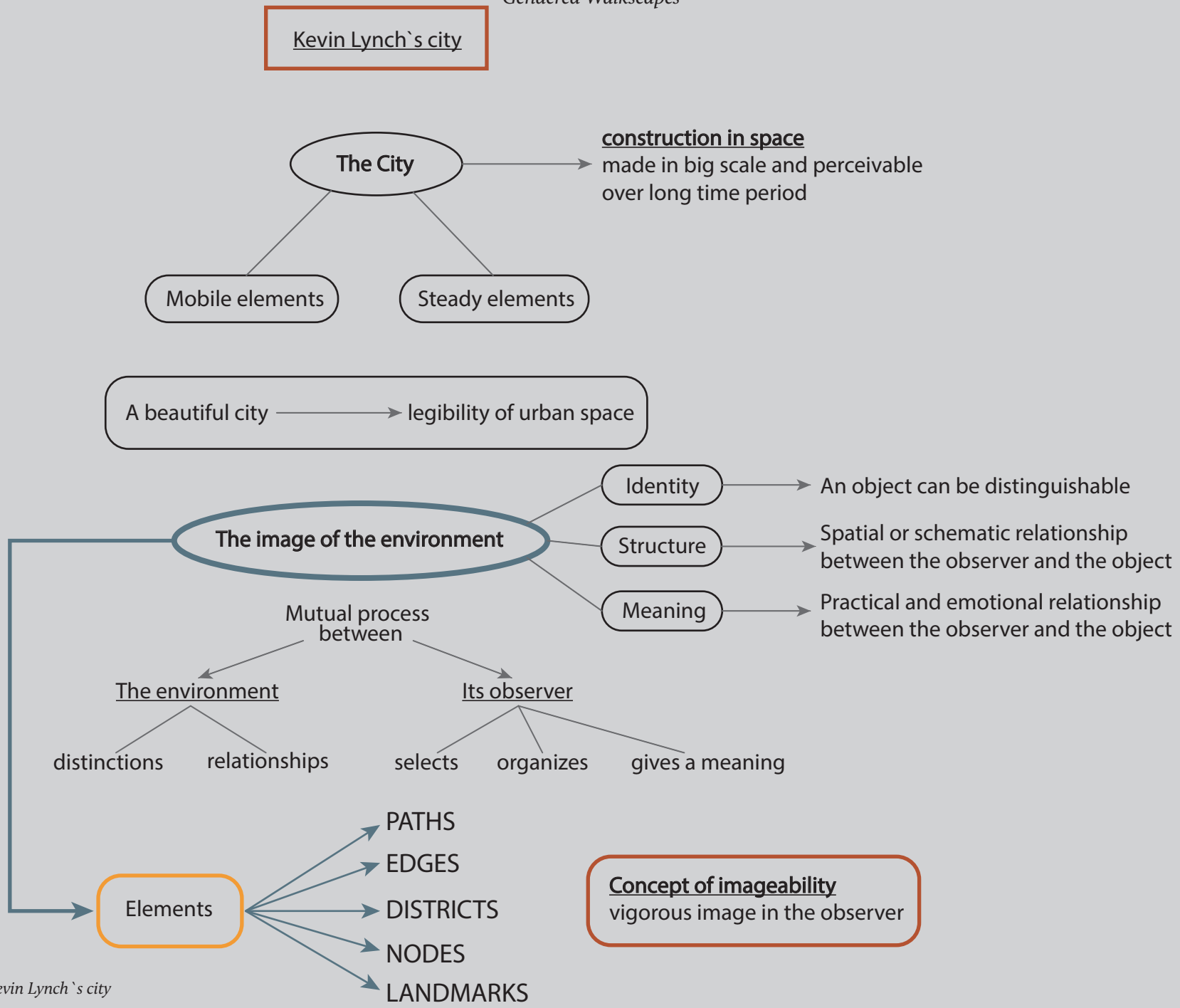


Figure 4: *Kevin Lynch `s city*

The eye-tracking method applied in an urban context

There are several investigations about applying the eye-tracking method in urban spaces. Some use static images of actual streets in their studies, while others are based on walking routes. All utilize surveys associated with the technology, a fixed number of people, and a defined method.

In the study made by the University of Cracow (Planning, 2018), eye-tracking technology was used to explore the visual perception of things and urban spaces in pictures. A mixed sample of 100 participants were involved in the test. The published results stated that architectonic components, like balconies and windows attract interest as well as all objects found in eye-level such as posters or fences, parked cars and road infrastructures. They all take points of attention and their style is not determined. (Planning, 2018)

Justin Hollander's studies connected to the experience and sense of place. Three of those are pertinent to be described (Hollander & Hollander, 2016) (Hollander, et al., 2019) (Hollander, et al., 2020).

The first one concerned investigating pedestrian's mental state and sense of space through a Boston walking route. The eye-tracking technology used for the experiment was the portable electroencephalography (EEG) monitor, which is capable of analyzing brain waves. The study presents results from a pilot test based on individualizing scale for the Cognitive Architecture (CA) principles. The CA principles taken for the test are "Edges", "*Patterns*", "*Shapes*", and "*Narrative*". Scales for principles are 1 if it is "rarely or not seen", 2 if it is "moderately shown" and 3 if it is "evident the entire route" (Hollander & Hollander, 2016). Conclusions were that people reacted to an urban place in an unconscious level of attention and reflection. However, this investigation uses a very limited number of participants. Moreover, dissimilar route-studies could have had different characteristics to discuss in the test, and the used technology gives an imperfect picture of what is going on in the working brain. (Hollander & Hollander, 2016)

The Cognitive Architecture (CA) principles (Sussman & Hollander, 2015) are taken into account by the second experiment as well. In contrast, on this case (Hollander, et al., 2019), all five principles for the framework were contemplated: edges, shapes, patterns, narrative, and biophilia. (Sussman & Hollander, 2015). The focus remained the person's response to the built environment (Hollander, et al., 2019). Instead of taking five mixed participants as in the previous pilot study, eighteen students were included in the test. Twenty actual pictures, including questions with a 1-7 scale, were shown to participants who wore the Remote Eye-tracking Device (RED), which is screen-based. This study showed how people become involved emotionally in urban spaces. Limitations for it were a restricted type of demographic groups and their background and profession.

In the last considered paper, which talks about understanding participant reactions through analyzing eye fixations when seeing traditional neighborhood design in images (Hollander, et al., 2020). The same method was

used. The conclusions from this study were that people ignore blank facades, because they are placed after orientation, faces, and other people. The built environment greatly influences people's sense of place, mental health, and well-being. (Hollander, et al., 2020)

Another research using the eye-tracking method concludes that spaces with cars and parking get negative perceptions from people when compared with pedestrian facilities and natural elements (Noland, et al., 2017). The experiment was made up of the following steps. Firstly, twenty participants were picked, and secondly, the images to present to participants were chosen. Then, the Tobii eye tracker was calibrated. Subsequently, surveys were associated to images. Finally, the eye movement analysis data was collected. (Noland, et al., 2017)

A workgroup from China and Taiwan made a different test using the eye-tracking technology in a Virtual Reality (VR) environment (Zhang, et al., 2019). VR is a platform used to investigate and recreate a virtual space that can potentially be the whole city or only a part of it. Combining it with eye-tracking tech, the huge quantity of data to take into account can be expanded from the typical unique use of eye-tracking because of the 3D environment. An urban design`s 3D model project could be readily examined in the development phase.

Three main parts constitute the experiment platform: "server, analog end, and data acquisition end" (Zhang, et al., 2019). Essentially, data from the eye-tracking with the VR headsets is put in the Unreal Engine. The software will convert thermal models and 3D point clouds (Zhang, et al., 2019).

This investigation's results are delivered with time analysis from the eye-tracking data, the survey, and the people's behavior during the Virtual Reality experience. An interesting fact that can be extracted is how the height of fixation points in heat maps varies depending on the participant's background. For example, a non-professional person pays attention to objects located at a lower altitude than a professional one. However, both groups identify the identical features and engaging things in a scene (Zhang, et al., 2019).

Discussion

The eye-tracking technology cannot be used alone since the site cannot be regarded as a whole. Many heat maps in images are incapable of giving an exhaustive telling of the place. Therefore, tools such as GPS tracking can be included in helping draw the flow of people and the proper position of pictures recorded by the eye tracker. That enables us to create more meaningful testings. But this is still not enough for the study. The survey could be another essential tool to combine. It gives significance to the attention`s points (*fixation points*) in heat maps, getting conclusions from the examined outcomes.

When combined with Virtual Reality (VR), the new technology could be a effective tool for designers. They could see and analyze in real-time both real situations and different scenarios. Also, recreation in a virtual reality environment could be useful in situations where it is impossible to reach a specific site. This approach is all new because the two technologies continue to be improved. Therefore, more investigations in the field are needed.

Eye-tracking can be a useful tool for the city. It can get a better understanding of the people's behavior, their sense of the place and give voice to all groups. Professionals can use this knowledge to improve their design or finding solutions to issues. Moreover, it is a very flexible, handy, smart tool.

Regarding the processes of the experiments, a fundamental step is defined by the pilot test. The method could be tested on a smaller scale and in the actual structure if doing the pilot test at the first instance. This phase can develop failures which could help to develop additional steps that help achieve better results. Furthermore, the technologies will be tested during this process, reducing the time in managing and mastering them during the real experiment.

To conclude, a strict method is required to use eye-tracking technology for analyzing the pedestrian perspective and overall feeling. Also, the use of surveys helps to connect the data to the investigated research question. Moreover, the test can be done both in the real world and by means of images.

Having different and specific demographic groups' samples becomes an essential factor that can influence the results. This factor along with the restricted number of participants determines a gap for the studies. It is also missing comparisons between the different groups.

Finally, different arguments can be used for different urban streets depending on their features or elements. That is why more research in the field is needed.

Conclusion

Data collecting outcomes are interpreted through heat maps in pictures or points in videos (Hollander, et al., 2019), showing participants' fixation points along the walking route. Then, GPS data registered during the experiment simultaneously with the eye-tracking recordings can be compared with these images or videos. That will give us the feeling of the overall space under review instead of having just sporadic pictures.

Finally, graphs could be drawn examining, for example, the frequency in seeing a piece of architecture or a thing in the urban environment or how much time the participant spent watching something.

Many facts can be deduced from such materials. Moreover, by intersecting the survey data with the eye-tracking data, outcomes can be discussed for different groups. Most probably, the architect participant, for example, focuses more on built features on the environment or specific architectural details. Non-professionals, on the other hand, will most likely have other focus points.

In the case that only two groups are taken into consideration, professionals with architecture backgrounds and non-professionals, several data results can be achieved (Zhang, et al., 2019). As heat maps show, the first group has points of fixation higher than the other group. They look carefully at windows, roofs, arches, etcetera. The second group has lower attention points, focusing on closer objects (Zhang, et al., 2019). Two different experiences are carried out by participants, but both are positive in the sense that they both find interesting different characteristics on the street proposed for the experiment.

Other findings could appear by finding elements like non-good building values or parked cars that seem to have fixation points with non-positive reactions by participants. These outcomes could help make a better urban design/regeneration and/or solve issues as well.

Figure 5: *Pupil Invisible glasses on, Aalborg town center*

Gender-sensitive planning

What makes a city sustainable and livable? According to the definition of sustainability, three principles are to be taken into account to achieve this: economy, society and environment.

For its inhabitants the city should develop strong strategies that take care of the people who live in it. This becomes even more important when considering long-term planning, given that the global population growth continues to increase. That is why 'Gender Mainstreaming', which focuses on implementing gender equality, can be one of those strategies ((EIGE), 2016).

'Gender mainstreaming' consists in detecting and analyzing people's needs and incorporating them in the city's plans, ensuring gender equality and high-quality urban planning (Damyanovic, et al., 2013).

How can gender-sensitive planning help in improving the quality of an urban space? Men and women have different needs through all life phases (Damyanovic, et al., 2013). Their behavior varies depending on the place they are or the situation they are in. That is why understanding and analyzing those differences in order to incorporate them into the planning could entail that the barriers between groups get demolished and that the quality of the urban space in terms of safety, accessibility, and inclusiveness is improved. (Damyanovic, et al., 2013)

This strategy can be also applied during all phases of the overall process (Damyanovic, et al., 2013). In this case, that would be the analysis phase.

Therefore, the collected eye-tracking data from the experiment will be compared and discussed between male and female groups.

The case of Vienna City

The city of Vienna has developed a "*Gender Mainstreaming*" strategy through several pilot projects (Damyanovic, et al., 2013). Therefore, nowadays, the City`s urban planning is based on gender-sensitive planning, working in achieving equalities for all process phases.

Taking into consideration the gender means investigating their differences in socio-cultural environment, life phases and situations (Damyanovic, et al., 2013). For example, girls and boys behave and use urban spaces differently. Girls are used to play quietly, while boys like physical plays, and so on. Then, the socio-ethnical background can influence the different behavior between gender school-age children, which can be boys are allowed to free go and use urban spaces more often than girls, etc. (Damyanovic, et al., 2013)

Regarding adults, this group is more complex than children or adolescents. It is needed to know about personal situations like profession, family scenario, mobility, lifestyle, special needs, etc. (Damyanovic, et al., 2013)

Gender-sensitive planning considers a huge number of variables and discrepancies between groups.

Therefore, applying this "*Gender Mainstreaming*" strategy can increase the quality of planning, which includes master plans and urban design concepts.

That is to give a foundation and the reason to compare and discuss the collected Eye-Tracking data from the experiment between male and female groups, solving a gap from the literature regarding the lack of comparisons between demographic groups.

Figure 7: *Vienna town center*

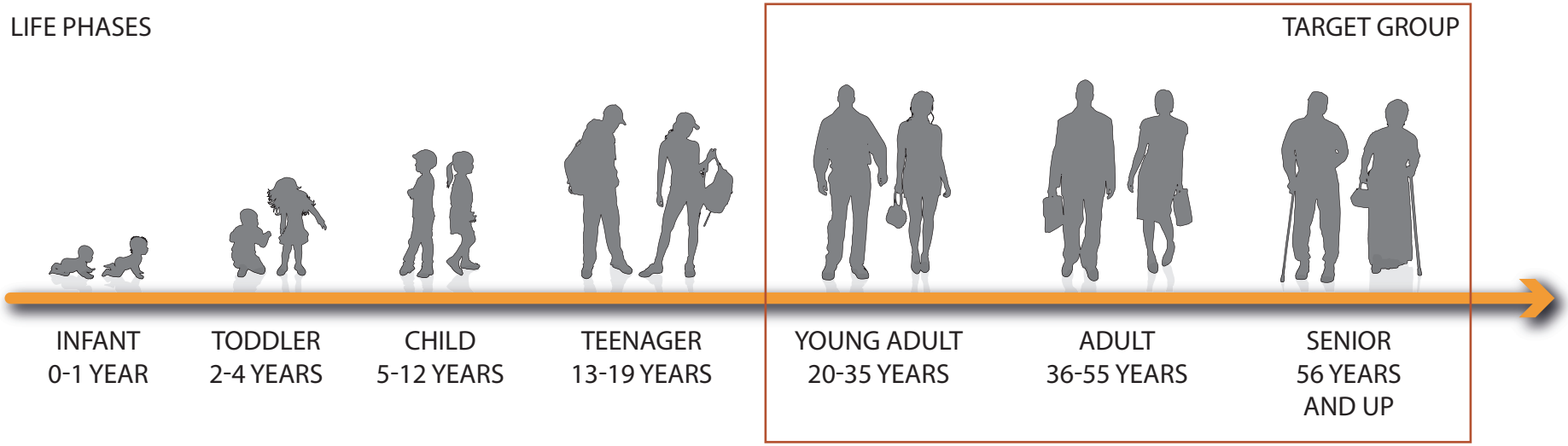


Figure 6: *Life phases*

VIENNA CITY

Figure 8: *Niels Ebbesens Gade, Aalborg city*

Methodology

The chapter focuses on the individualization and description of the right method for the Eye-tracking investigation. The process will be explored together with the definition of the experimental framework. Finally, the target group will be set out.

Experimental design

The type of methodology used for this dissertation is experimental design. This method consists of setting and executing fixed steps for later combining and discussing the outputs, which are eye-tracking data, GPS data, and surveys.

In order to design an experiment, a standardized and replicable procedure must be followed. All variables have to be identified, and the analyses' results must be written down meticulously (Duchowski, 2017). The framework will take into consideration six subjects: "Hypothesis", "Design", "Participants", "Apparatus", "Procedures", and "Tasks". (Duchowski, 2017)

1. **Hypothesis**: Before starting and when doing any experiment is fundamental to formulate a hypothesis. It can be represented by the research question. Moreover, it helps to achieve the desired results and to draw a well done and precise experiment. In an experiment, usually, the null hypothesis is assumed against the alternative one. That means that if the null hypothesis is confirmed in the end, then the alternative hypothesis will be rejected, and vice-versa. Additionally, it is key to distinguish between the independent and dependent variables. An example for a null hypothesis for the eye-tracking method when applied to an urban environment could be "Architectural buildings receive more fixations than shops" or "Parking areas have negative responses by people". Therefore, the alternative hypothesis could be "Shops receive the most points of attention" or "People have positive perceptions to parking areas" respectively. This way, the results could confirm or not the hypotheses, and conclusions could be drawn in both cases. Following the example, in this case, the independent variable could be the fixed route or images for participants. In contrast, the dependent variables that could influence the outcomes could be the weather, the mental state of participants in day the experiment is carried out, or simply the different demographic groups.
2. **Design**: After defining the hypothesis, the design of how to manage the independent variable in order to achieve or not generalized results has to be set.
3. **Participants**: The chosen demographic groups and number of participants have to be stated with their characteristics anonymously detailed.
4. **Apparatus**: All the technologies used for the experiment must be put down in writing together with their specifications and properties.
5. **Procedures**: The definition has to include the instructions for participants and the eye-tracking calibration.
6. **Tasks**: It defines the final subject of this framework.

Experiment´s framework

1. **Hypothesis**:

   Null hypothesis = A) Shops and urban arts get more fixation points. B) Greenery in the street receives positive grades. C) Parked cars through the street give negative feelings.

- *Alternative hypothesis* = A) Participants are not interested in shops and urban arts. B) People do not care about the presence or not of greenery in the street. C) The presence of parked cars is accepted by pedestrians.

- *Independent variable* = Adult and senior groups.

- *Dependent variable* = The appointed route in the Aalborg Town Center. The walking route defined by the following streets: Niels Ebbesens Gade, Bredegade, and Algade.

2. **Design**: The independent variable is compared between male and female groups taking into account the gender perspective of the streetscape in order to get generalized results.

3. **Participants**: Nine participants are involved in the test:

- *Test 1*: Male, 36 years old, architectural engineer.
- *Test 2*: Male, 64 years old, restaurant manager.
- *Test 3*: Female, 68 years old, retired .
- *Test 4*: Female, 30 years old, singing teacher.
- *Test 5*: Female, 28 years old, unemployed.
- *Test 6*: Male, 46 years old, waiter.
- *Test 7*: Female, 47 years old, day care.
- *Test 8*: Female, 40 years old, secretary.
- *Test 9*: Male, 42 years old, professor.

4. **Apparatus**: *Pupil Invisible Glasses* (GmbH, 2021) : outdoor eye-tracking, video-based. Main specifications:

- Normalized 2d gaze positions for gaze data
- No calibration needed
- "*200Hz @ 192x192px IR illumination for eye cameras*" (GmbH, 2021)
- "*30Hz @ 1088 x 1080px 82°x82° FOV for detachable scene camera. Square aspect ratio covers full field of view*". (GmbH, 2021)
- "*Gaze data at 66Hz and world video for real-time streaming*" (GmbH, 2021)
- "*Robust for all environments*" (GmbH, 2021)
- "*Works on the majority of people*" (GmbH, 2021)

Pupil Player v3.2.20 software to export data from the eye tracker.

Apple Watch with "Strava" app used as GPS-tracker.

5. Procedures:

Instructions for participants

On the appointed day, the participant was met at the area among the streets of *Niels Ebbesens Gade*, *Kayerødsgade*, *Frederikstorv*, and *Danmarksgade*. There, a questionnaire about his/her gender, age, and profession was asked to be filled.

Afterwards, the walking route to be followed was shown (Niels Ebbesens Gade, Bredegade, and Algade streets). Later, the Pupil Invisible glasses were presented to the subject and connected to the "Companion Device".

Before starting the walk and the record of data, an Apple Watch with the installed Strava app was given to the participant to map the route.

Finally, when rejoining the meeting area once the walk is done, the participant filled up a survey about his feelings regarding the presence of greenery, parked cars or shops he/she encountered as well as their perception of the built environment.

The experiment was carried out following the present COVID-19 virus prevention directives: taking a COVID test beforehand, wearing a mask and applying hand disinfectant.

The questionnaire and the survey are anonymous.

The questionnaire and the survey:

a https://forms.gle/csAxWcfb3BedgCmK7

b https://forms.gle/GekXKnuTvHAK78Es6

a b

Tasks: The task for participants was to wear eye-tracking glasses, to take the GPS device with them, to take a walk through the appointed street of Aalborg and to complete a survey.

Figure 9: *Pupil Invisible components*

Figure 10: *Glasses detail. Near-infrared light and small camera*

Figure 11: *Glasses detail. Near-infrared light and the two cameras*

Phases for the process

The process has been split into six phases:

1. **Research around the specific street in Aalborg City.**

2. **Search for demographic groups to involve in the experiment.**

3. **Set up the instructions and surveys.**

4. **Carry out a pilot test first and, subsequently, the rest of the tests afterward.**

5. **Compile all data on the laptop, process and analyze it.**

6. **Devise outcomes.**

1. It could be unfeasible to analyze the whole city at once. The idea, then, was to choose a streetscape, where there could be issues, specific characteristics, or objects that could be useful for investigation. In the city of Aalborg, the candidates to explore potentially were Nytorv, Østerågade, or Vesterbro. Therefore, a preliminary study of the selected sites was needed. In this specific instance, the experiment's route was set to be through the Niels Ebbesens Gade, Bredegade, and Algade streets in Aalborg. Here, the main streetscape's features are greenery, pedestrian areas, parked cars, historical and characteristic buildings, and shops.

2. Finding the right participants is a delicate subject to reach for any experiment. They should be well-mixed. The focus could be on different ages and professionals, gender, tourists and citizens, and etc. (Vainio, et al., 2019)

3. Defined the participant groups, it is then necessary to compose a survey (Hollander, et al., 2019) with questions regarding topics like name, birth date, nationality, profession, frequency of study street passed along, etcetera. Finally, participants get instructions and paths to follow, and at the end, a second survey asking them for feedback about their feelings and preferences.

4. Making a pilot test beforehand allows us to inspect the functionality of the experiment's procedure and to get familiar with the technology.

5. After the experiment is carried out, the recorded data was put on and processed with the specific software by Pupil Labs (GmbH, 2021): Pupil Player (Pupil Labs, 2021) which is based on mathematical logarithms. Then, the resulted videos were analyzed through Elan software (The Language Archive, 2021).

6. Finally, outcomes were understood and discussed by combining the survey with GPS data.

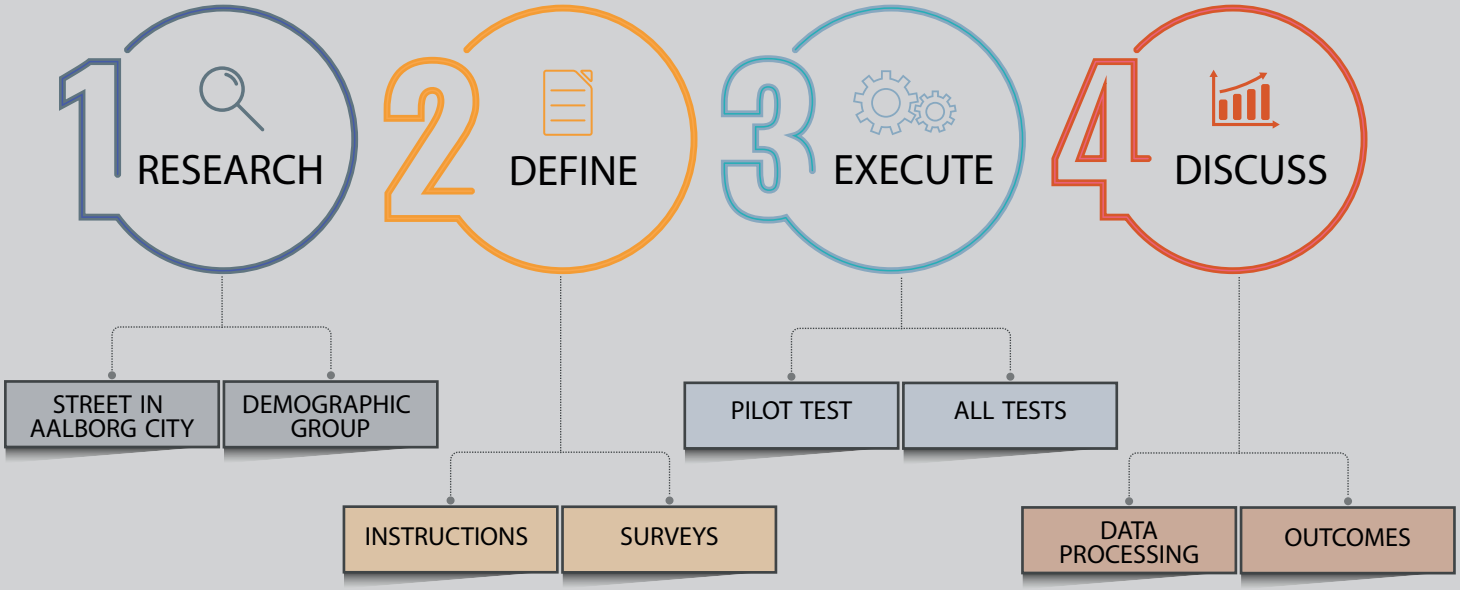


Figure 12: *Process phases*

Streetscape

Figure 13: *Aalborg City. Shared space, road, and greenery*

According to "Collins Dictionary", "Streetscape" is "*a pictorial view of a street*" (Collins, 2021) or "*an environment of streets*" (Collins, 2021). Both can be seen as inseparable definitions. The pedestrian sees the street as a picture and lives its surroundings at the same time. Thinking on that, it is not taken for granted its evaluation, because a lot of aspects come into account to analyze such as space. All depends on people: its demographic, its mood at a specific time, its background, etc. It becomes a very complex subject to discuss.

The features to look at will be buildings, stores, objects, roads, sidewalks, and greenery.

In the specific case, the streetscape includes historical buildings, shops, a public green area, trees, squares, sidewalks, a pedestrian area, a shared space, and a road.

Target group

A representative sample of adult and senior groups has been set for the experiment. There were seven adult participants with different professions, three males and four females, with an age gap between 28 and 47. Also there were two senior ones, one male and one female, with ages respectively of 64 and 68.

Due to the available resources and the impending deadline, the set number of participants was not large. The COVID-19 pandemic breakout made it difficult to find people eager to get involved in the test, so there were nine participants in total.

Finally, in order to contemplate the gender perspective, to find data gaps and to achieve the gender equality of the streetscape according to the Gender mainstreaming strategy (Damyanovic, et al., 2013), male and female groups were compared.

Test number	Gender	Age	Profession
Test 01	Male	36	Architectural engineer
Test 02	Male	64	Restaurant manager
Test 03	Female	68	Retired
Test 04	Female	30	Singing teacher
Test 05	Female	28	Unemployed
Test 06	Male	46	Waiter
Test 07	Female	47	Day care
Test 08	Female	40	Secretary
Test 09	Male	42	Professor

Figure 14: *Participants table*

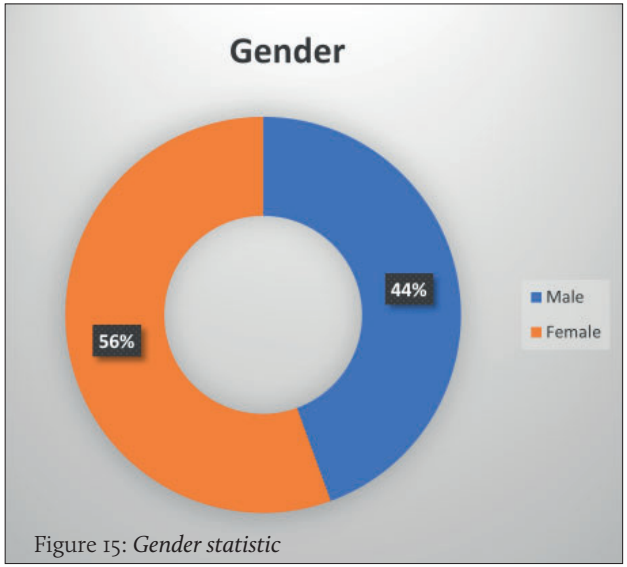


Figure 15: *Gender statistic*

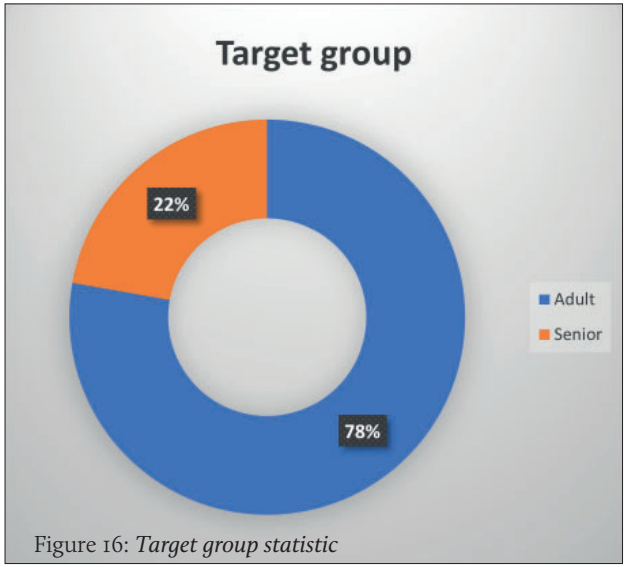


Figure 16: *Target group statistic*

Study site

This chapter will introduce the study site. The walking route is defined and analyzed through site analyses. The scope is to well-understand the site for the experiment in order to set specific and meaningful hypotheses and surveys for the investigation and participants.

Figure 17: *Study site. Roads and buildings*

Walking route

The study site for the investigation is situated in the Aalborg town center, in Denmark. The walking route is among Niels Ebbesens Gade, Bredegade, and Algade streets. Three main roads, Nytorv, Boulevarden, and Danmarksgade, mark the boundary of this path. Features like greenery, pedestrian areas, parked cars, historical and characteristic buildings, shops, and squares, define the identity of the streetscape.

The walking route can be divided into two parts: the first is mainly characterized by a road, a green public area, and the state archives; the second one is a pedestrian area with shops, including a small "shared space" nearby the church.

Figure 18: *Walking route*

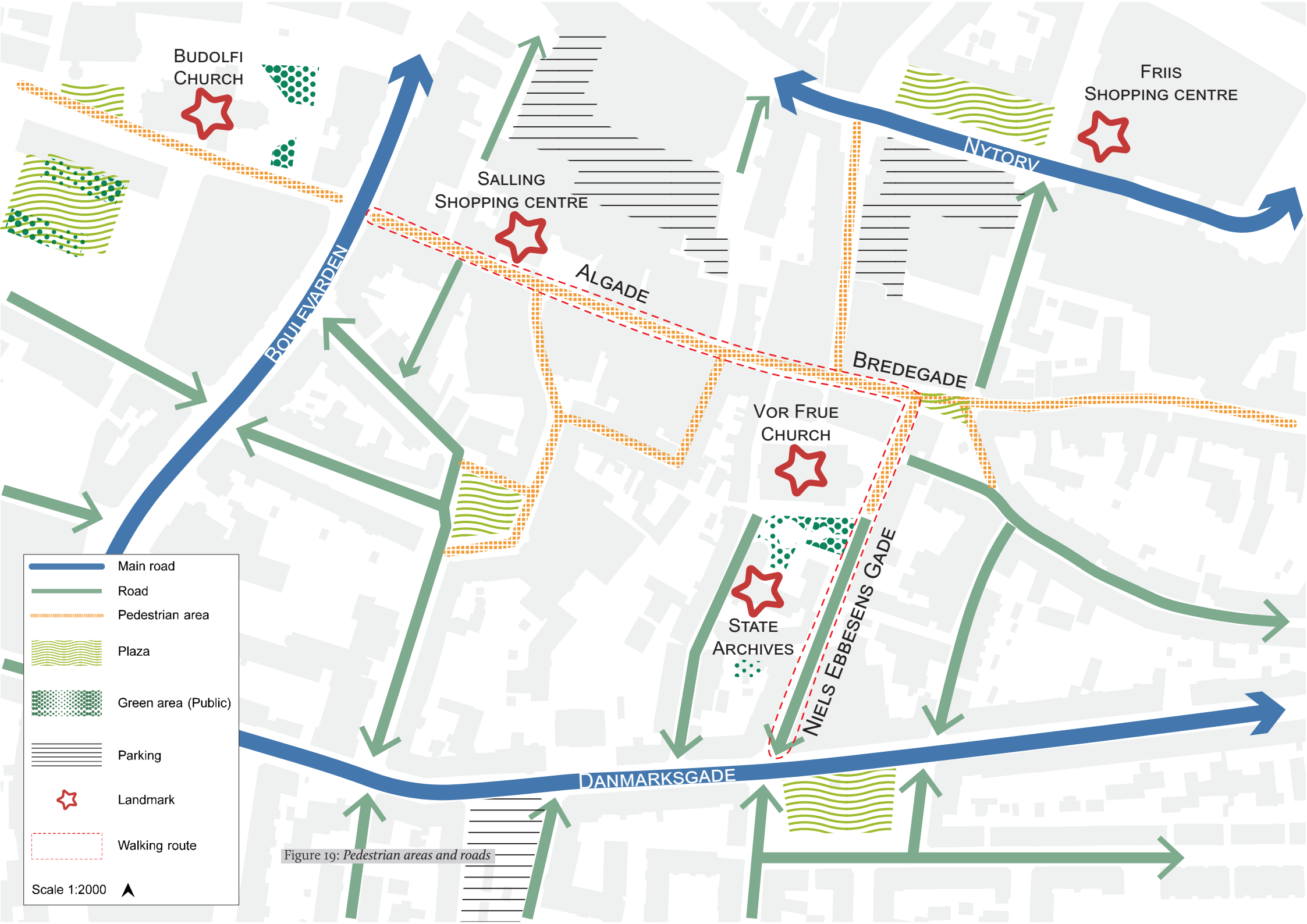


Figure 19: *Pedestrian areas and roads*

Legibility analysis

The legibility analysis is based on the individualization of the five elements that constitute the mental map, according to Kevin Lynch, stressing the importance of the human experience. That allows the street to work properly regarding pedestrian mobility as well.

Elements are "*Paths*", that are the actual pedestrian routes; "*Edges*", which give people the sense of boundaries along the path, which in this case are roads and shops; "*Districts*", that are medium or large areas with the same features: a green public area for the case; "*Nodes*", which are areas for orientation along the way, like squares; and "*Landmarks*", that are points for orientation outside the pathway: they identify the specific urban place.

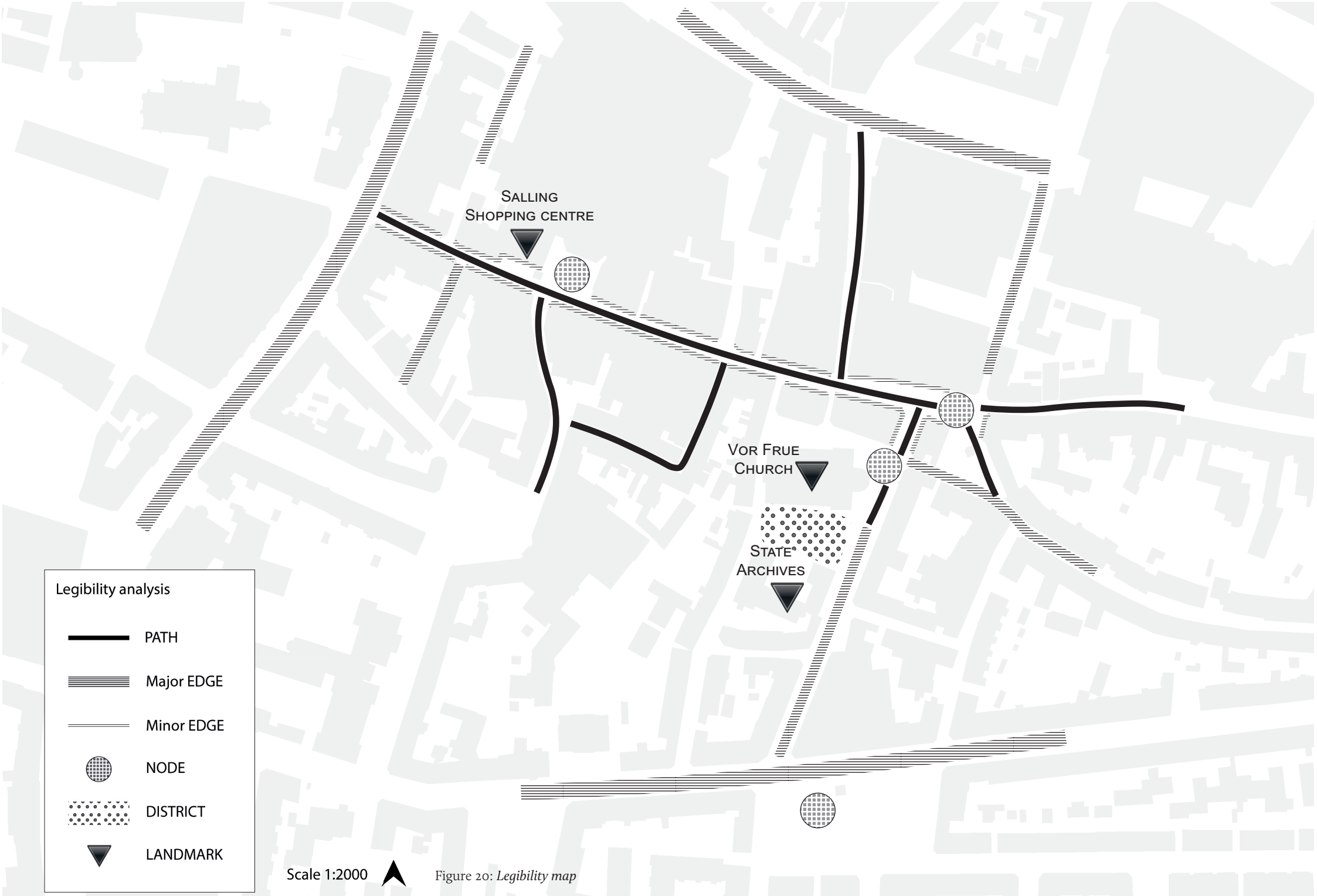


Figure 20: *Legibility map*

Pedestrian flow

This analysis clearly shows how the pedestrian moves on the study site and where discontinuities are. The shared space lessens the transition from the road to the pedestrian area near the church.

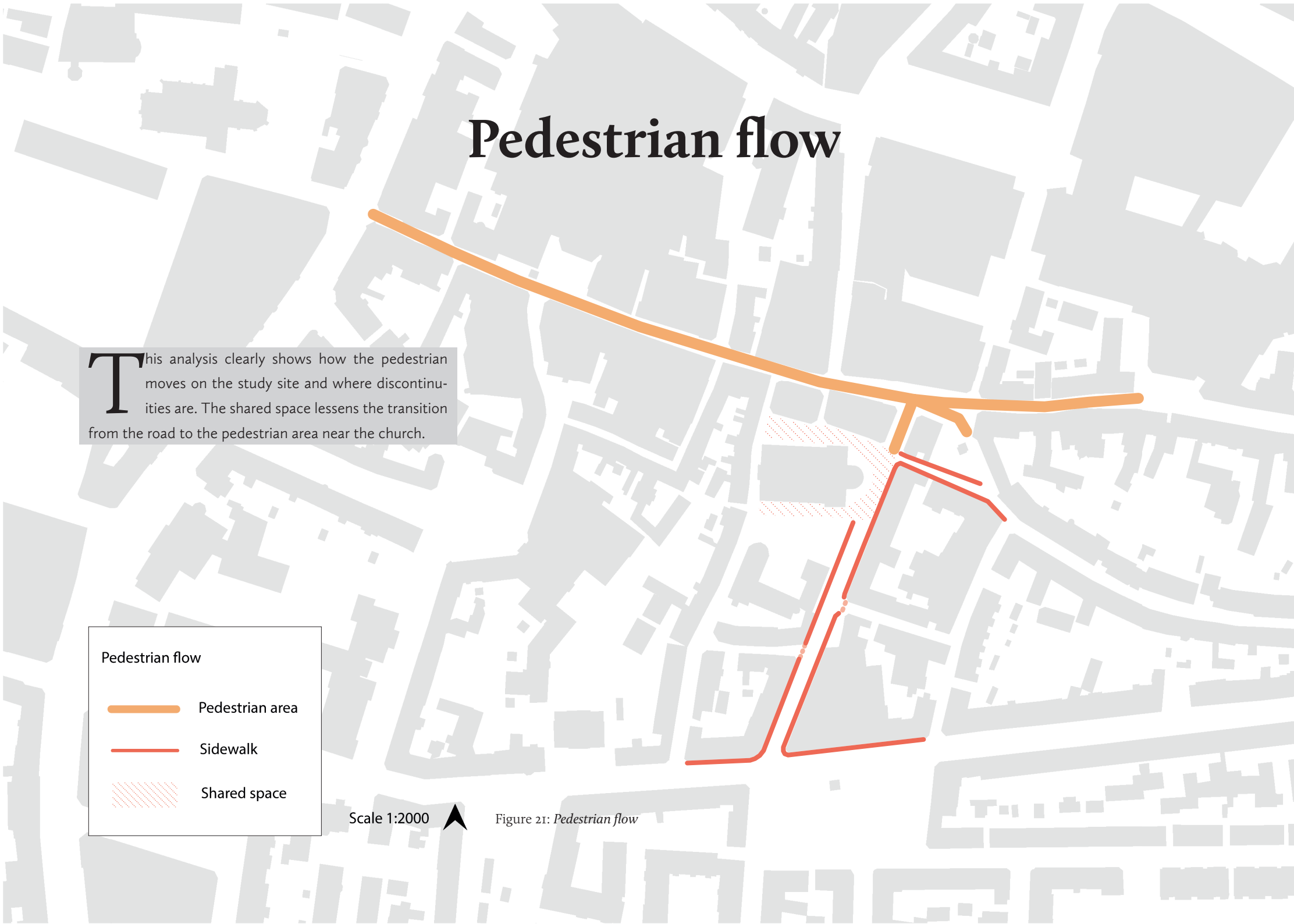
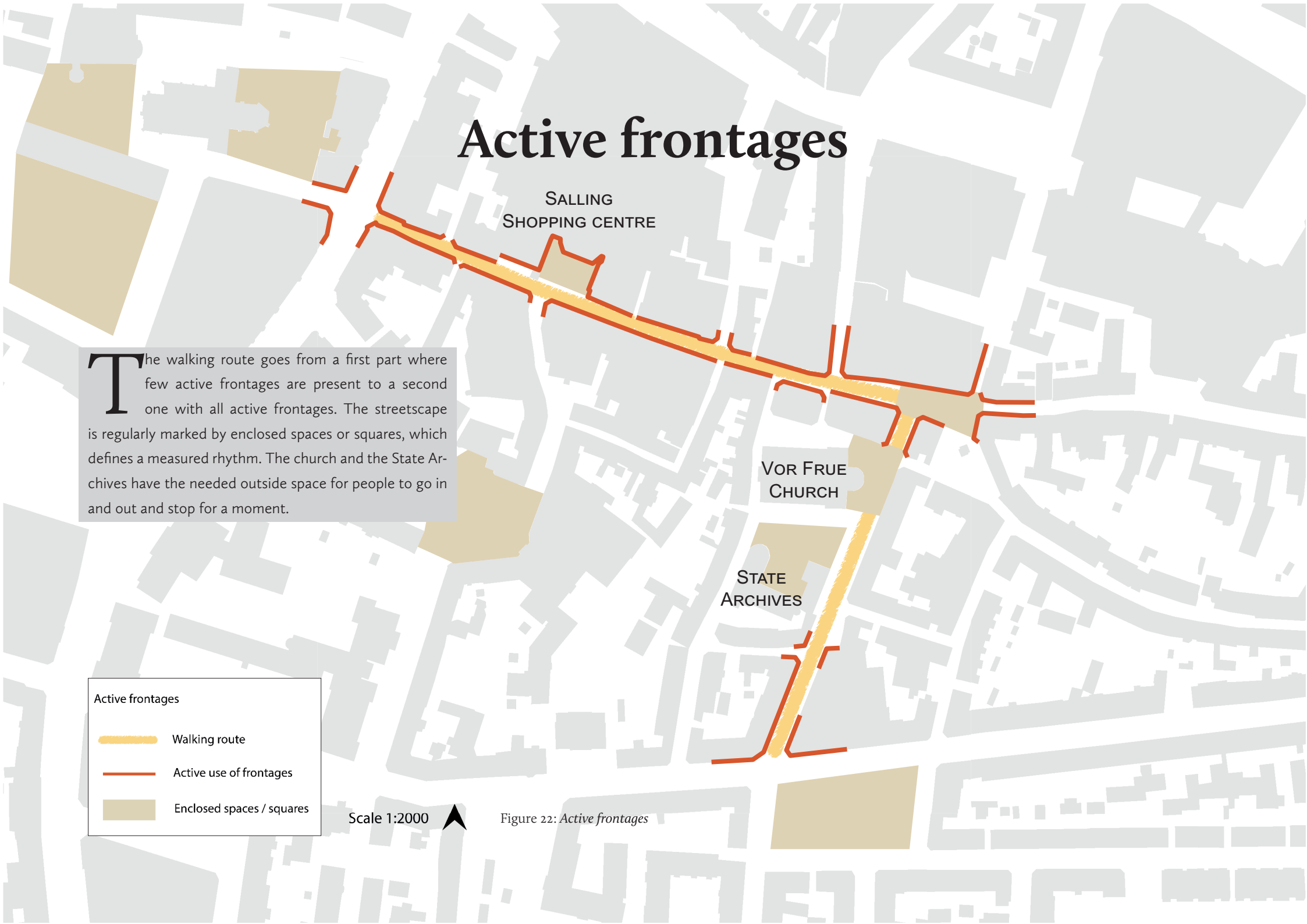


Figure 21: *Pedestrian flow*

Active frontages



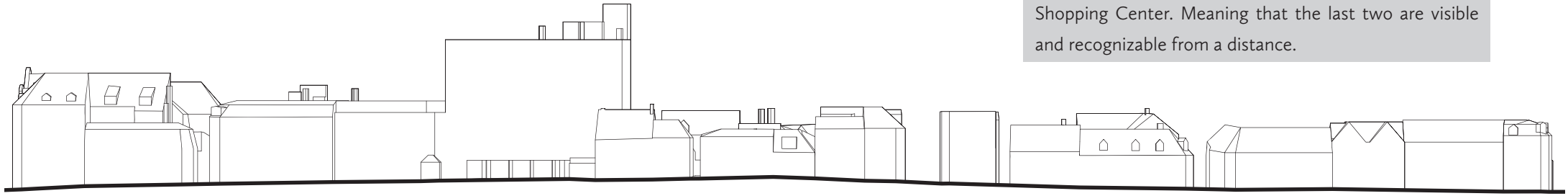
The walking route goes from a first part where few active frontages are present to a second one with all active frontages. The streetscape is regularly marked by enclosed spaces or squares, which defines a measured rhythm. The church and the State Archives have the needed outside space for people to go in and out and stop for a moment.

Figure 22: *Active frontages*

Elevations

Analyzing the elevations, it can be inferred that the walking route is almost a level road. The shopping pathway has none or at least a few empty spaces between buildings, while the street with historical buildings has large empty spaces.

Looking at the building heights, almost the same height is there except for the church building and the Salling Shopping Center. Meaning that the last two are visible and recognizable from a distance.



Elevation AA - Scale 1:1000

Elevation BB - Scale 1:1000

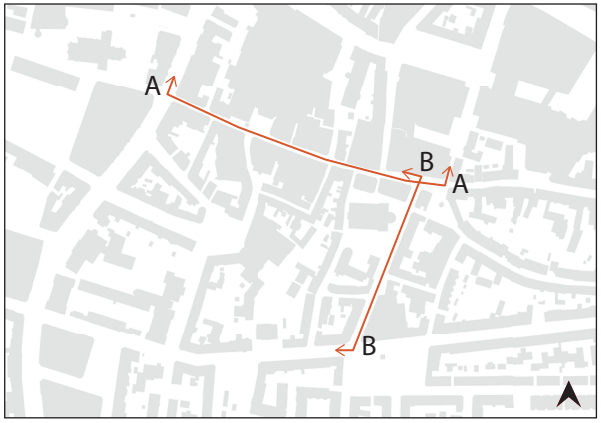
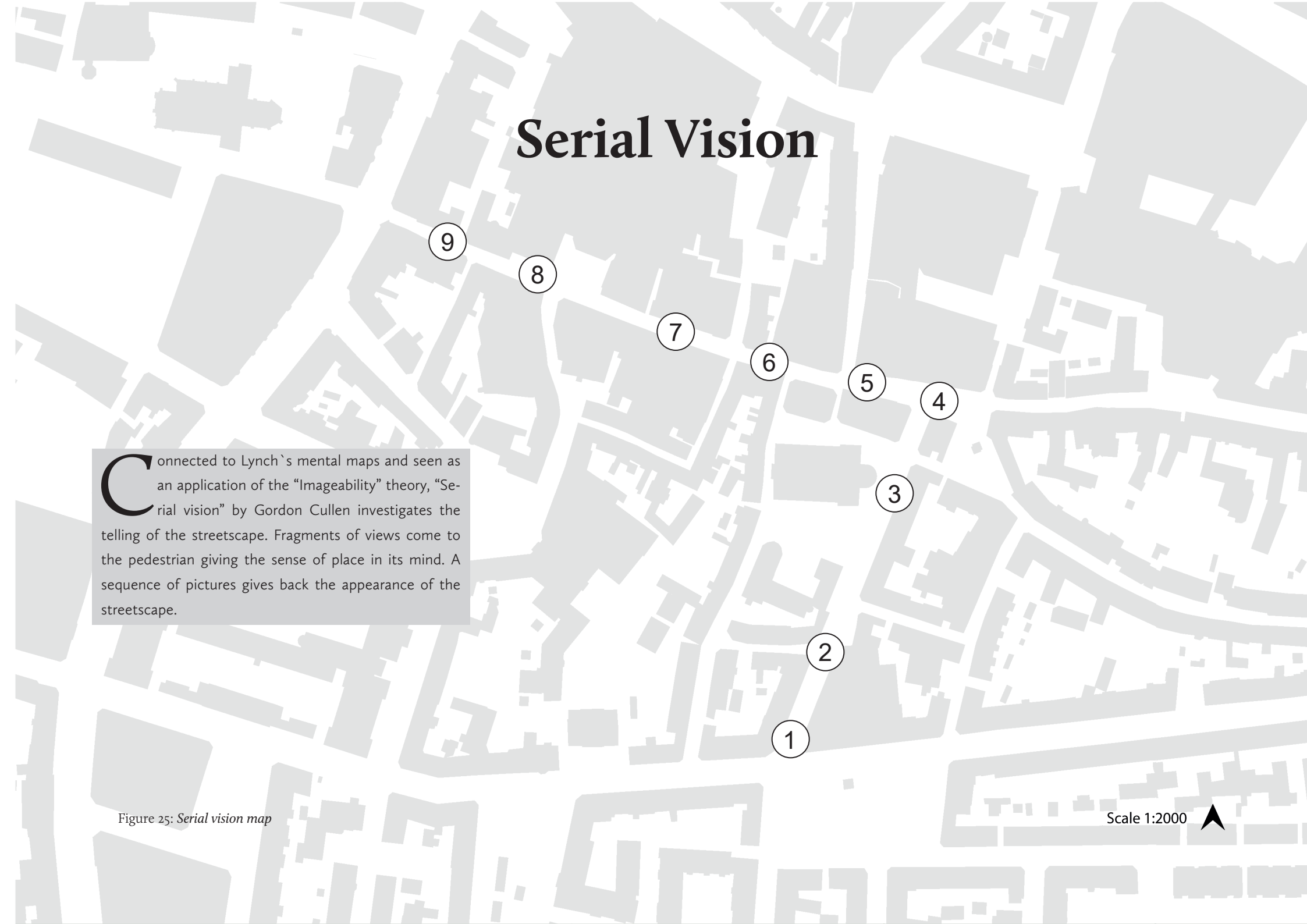


Figure 23: *Elevations*

Figure 24: *Aalborg City. Salling outside area*

Serial Vision



Connected to Lynch`s mental maps and seen as an application of the "Imageability" theory, "Serial vision" by Gordon Cullen investigates the telling of the streetscape. Fragments of views come to the pedestrian giving the sense of place in its mind. A sequence of pictures gives back the appearance of the streetscape.

Figure 25: *Serial vision map*

Figure 26: *Serial vision pictures*

Figure 27: *Green area in Niels Ebbesens Gade, Aalborg City*

Results

The results from the experiment will be included in this chapter. They will regard the GPS mapping made by an Apple Watch, survey statistic data about participants and their perception of the streetscape, and Eye-tracking data analysis.

GPS mapping data

The GPS, or Global Positioning System, is a technology that can be used for tracking people. It allows us to gather data that contains information about both time and space.

During the experiment, an Apple Watch was used as a GPS device. The app used for recording data was Strava (Strava, 2021). Then, the GPX data was processed through QGIS software (QGIS, 2021) and visualized on the map, where each point of the resulted line was associated with a place and a time.

The start point was set at the intersection of Niels Ebbesens Gade and Danmarksgade. The end one was at the intersection of Algade and Boulevarden streets. On average, the time employed to walk the route was 10 minutes.

Finally, after fixing the path according to the map in QGIS, the touched buildings were detected along the way. [*See the map on the next page*]

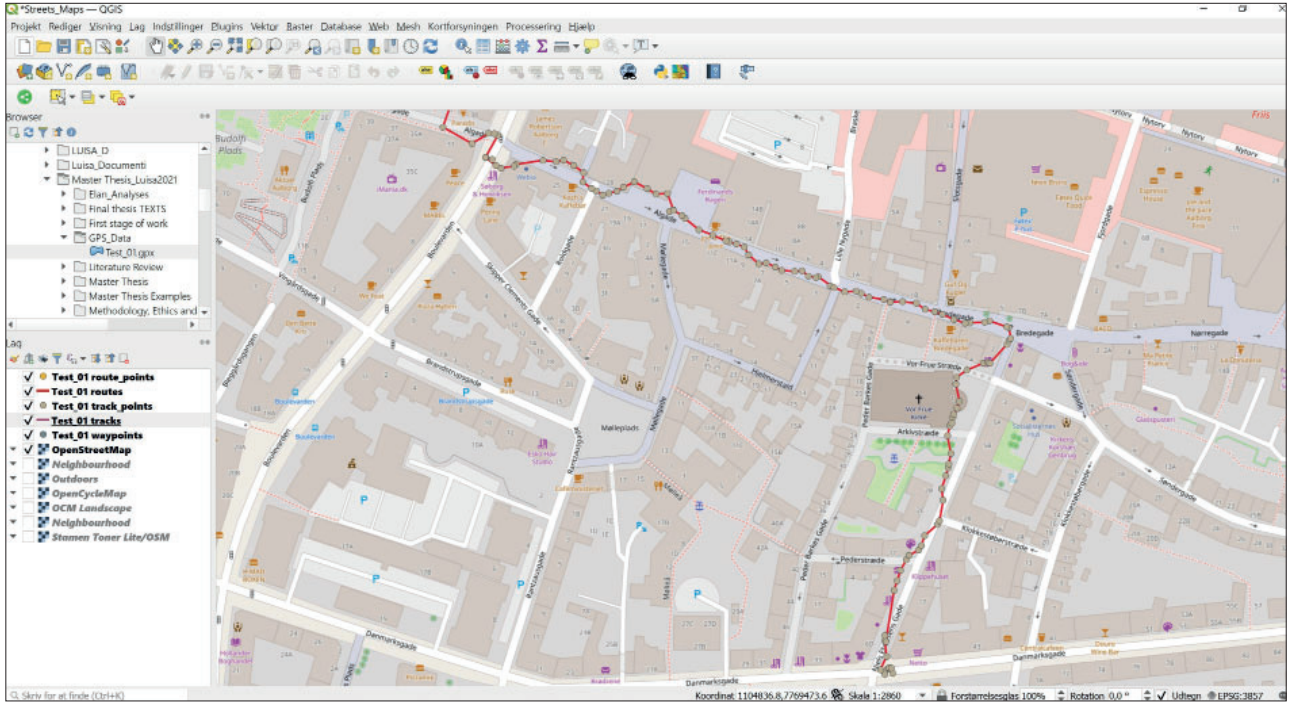


Figure 28: *GPS path to be fixed in QGIS software*

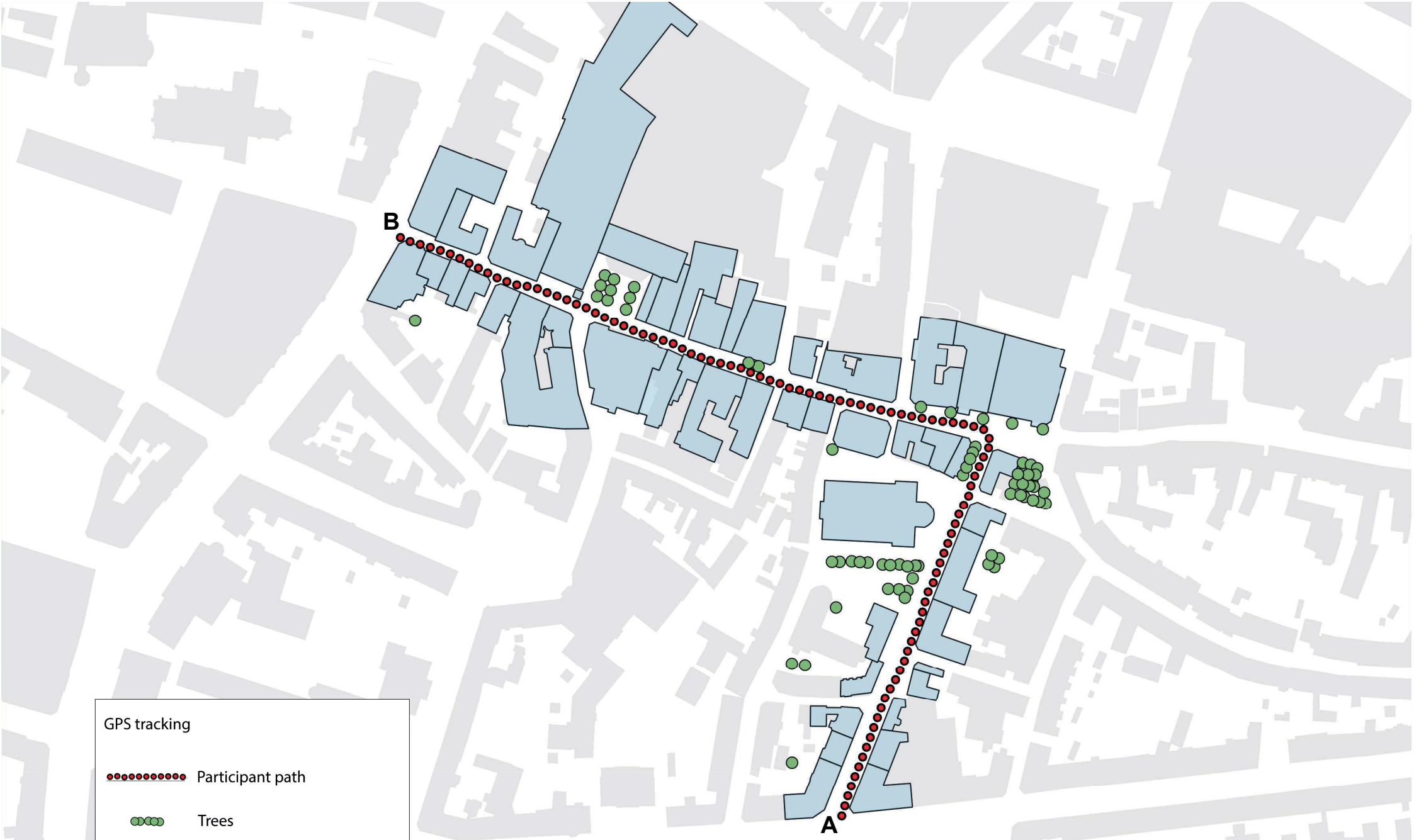


Figure 29: *GPS tracking path*

Surveys

Participants completed two surveys, one before wearing the eye tracker and starting the walk, and the other one after the end of the eye-tracking test.

The first one consisted of a questionnaire about the subject: gender, age, and profession of the participant. That was to be able to categorize him or her in the right age and gender group. Moreover, knowing their profession allowed us to partially draft the participant's background.

Out of the nine participants, 56% were females and 44% were males, with nine different ages and professions [*See figure 30*]. Seven of them, a 78%, were categorized in the adult group with ages ranging between 28 and 47; while two of them, 22%, were inserted into the senior group with ages of 64 and 68 respectively.

The second survey aimed to illustrate the feeling of the encounter of the subjects with the streetscape and their notice of its features, like greenery or parked cars, along the way [*See appendix for details and statistics*].

1. 56% noticed the green on the way; 33% did not notice the green on the way; 11% were not sure/can't remember.

2. 56% felt pleased when looking at greenery; 33% didn't notice it; 11% felt relaxed looking at greenery.

3. 89% noticed parked cars on the way; 11% did not notice them.

4. 78% felt indifferent towards the parked cars; 11% felt displeasure when looking at them; 11% did not noticed them.

5. The transition from the road to the pedestrian area in Niels Ebbesens Gade felt easy for a 64% of participants; unsafe for a 9%; safe for a 9% and achievable for an 18%.

6. 89% like urban art; 11% feel indifferent towards it.

7. 56% feel most relaxed and enjoyed themselves the most during the second part of the walking route represented by the streets of Bredegade and Algade (pedestrian area); 11% did so in the first part of the route represented by the street of Niels Ebbesens Gade; 33% in both parts.

8. 67% could deduce the narrative/change of historical elements of the street along the way; 33% could not.

9. 89% noticed historical buildings; 11% did not.

10. 23% rated five to the overall quality of the urban street; 22% rated six; 22% rated seven; 11% rated eight; 11% rated nine; 11% rated ten.

Test number	Gender	Age	Profession
Test 01	Male	36	Architectural engineer
Test 02	Male	64	Restaurant manager
Test 03	Female	68	Retired
Test 04	Female	30	Singing teacher
Test 05	Female	28	Unemployed
Test 06	Male	46	Waiter
Test 07	Female	47	Day care
Test 08	Female	40	Secretary
Test 09	Male	42	Professor

Figure 30: *Participants for the Eye-tracking experiment*

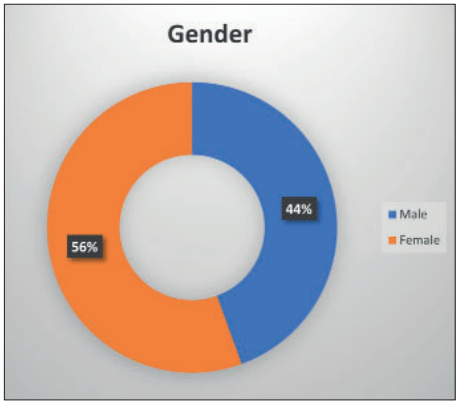


Figure 31: *Percentage of gender involved*

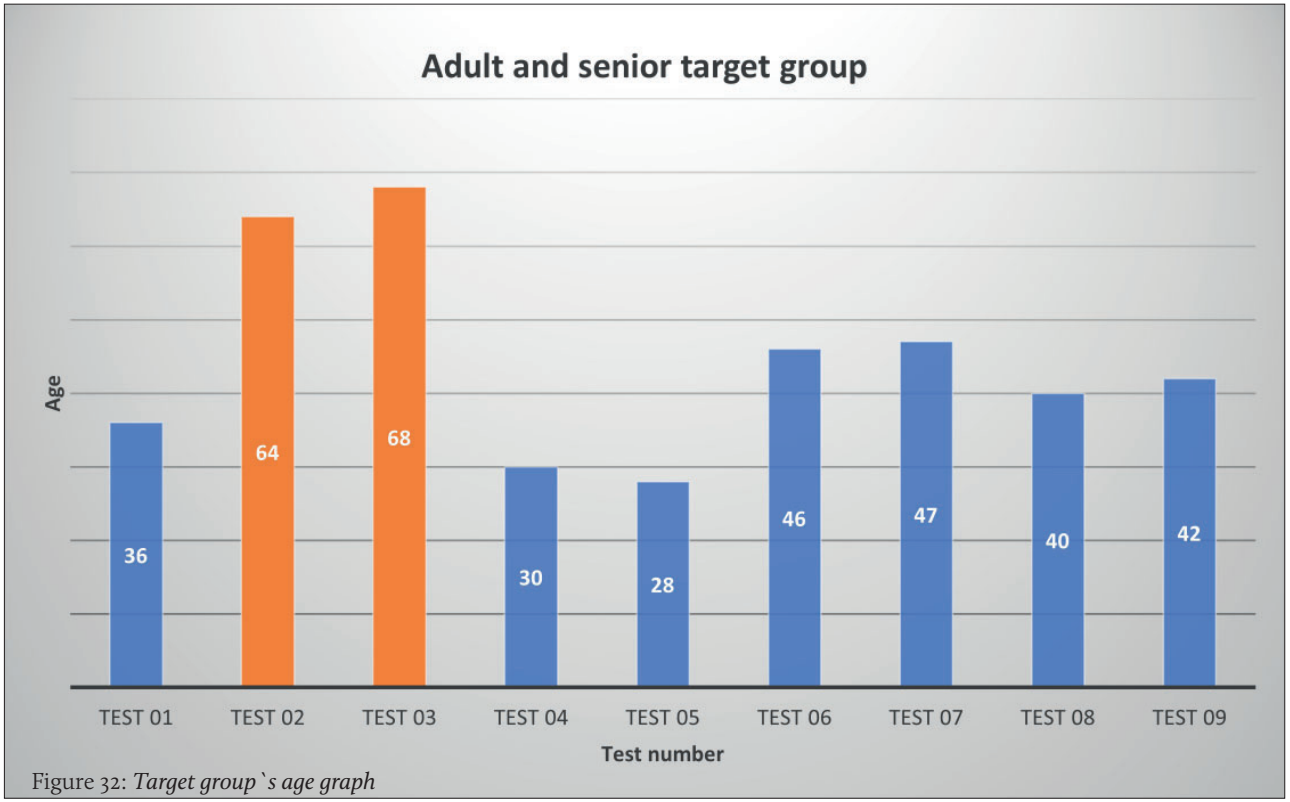


Figure 32: *Target group`s age graph*

Data analysis

After the eye-tracking tests, the Pupil Invisible Companion device which recorded eye-tracking glasses´ data was connected to a laptop and data were downloaded. Afterwards, data was processed in the open-source *Pupil Player* software (Pupil Labs, 2021). Then, the resulted videos with fixation points in full view [*See appendices for all videos*], were analyzed through *Elan* software (The Language Archive, 2021), where Tiers (Categories) based on hypothesis, were identified: shops, parked cars, historical buildings, greenery/trees, people, and urban art. Finally, outcomes from the software were examined in Microsoft's Excel.

Tests were divided into two main groups: the first considered participants met in the weekend at 9:30, while the second included participants who took part of the experiment during the weekend at 15:30. This is an important thing to take into account because, as it can be seen from the analyses, people tend to reach out to other people. Therefore, taking the test in different times indicates encountering fewer or more people along the route, meaning that fewer or more fixation points on people by participants are shown in the videos, thus affecting the results. Furthermore, to compare groups according to the experimental design methodology, they need to have the same characteristic (gender) and the same conditions: both same path and also same amount of people along it.

Five tests, including two males and three females, met in the weekend at 9:30 at the square among the streets of Niels Ebbesens Gade, Kayerødsgade, Frederikstorv, and Danmarksgade. On the other hand, four participants, two males and two females, met in the weekend at 15:30. Fewer people were present at 9:30. More people were present at 15.30. [*See appendix for details*]

The frequency of fixation points gotten for each category was determined in all tests [*See appendix for details*]. Then, statistics were compared between male and female groups.

The following results are not meeting time-sensitive:

- "*Urban art*" got 79% of fixation points from the female group. 21% from the male group.
- "*People*" got 68% of fixation points from the male group. 32% from the female group.
- "*Greenery/trees*" got 53% of fixation points from the male group. 47% from the female group.
- "*Historical buildings*" got 64% of fixation points from the female group. 36% from the male group.
- "*Parked cars*" got 51% of fixation points from the female group. 49% from the male group.
- "*Shops*" got 59% of fixation points from the female group. 41% from the male group.

The following results are meeting time-sensitive. Here, the frequency in percent of fixation points gotten from a category between male and female groups is shown:

	Urban art		People		Greenery/trees	
Meeting time	Male	Female	Male	Female	Male	Female
at 9.30	24%	76%	54%	46%	52%	48%
at 15.30	11%	89%	76%	24%	55%	45%

	Historical buildings		Parked cars		Shops	
Meeting time	Male	Female	Male	Female	Male	Female
at 9.30	37%	63%	41%	59%	37%	63%
at 15.30	33%	67%	62%	38%	48%	52%

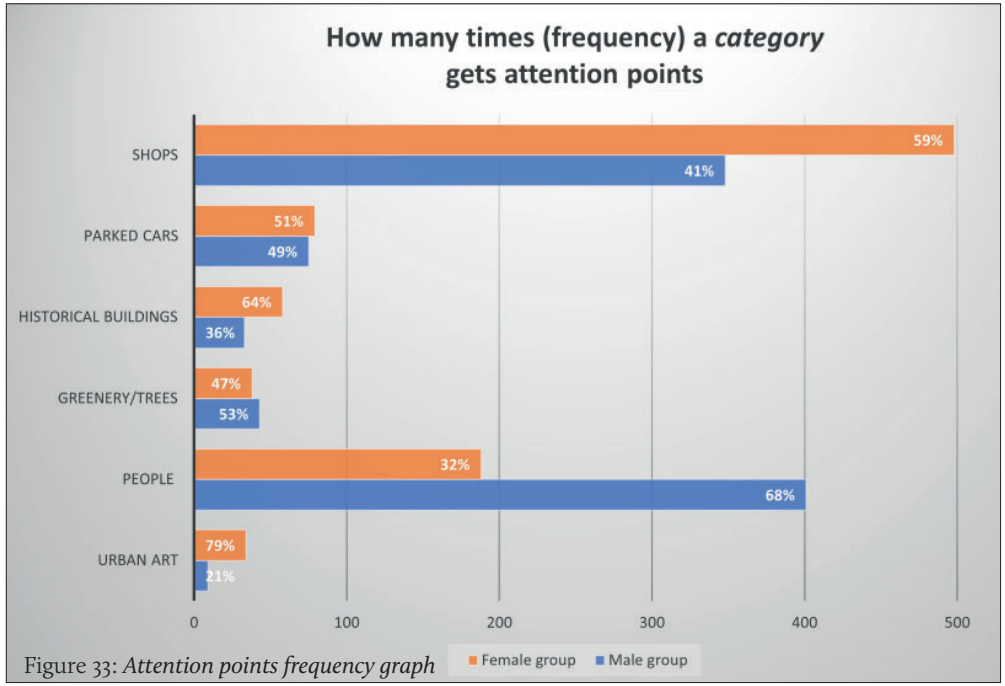


Figure 33: *Attention points frequency graph*

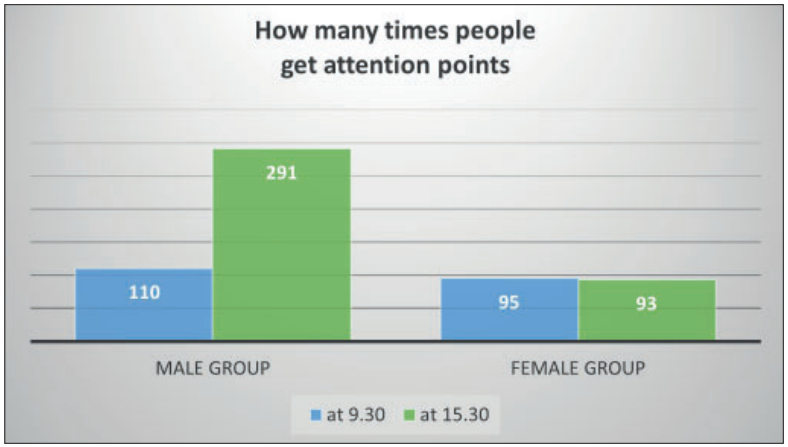


Figure 34: *Attention points frequency for people as a category*

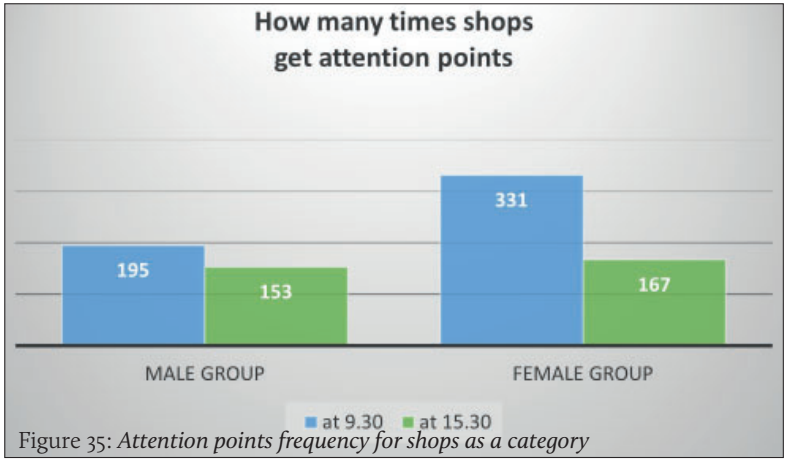


Figure 35: *Attention points frequency for shops as a category*

Discussion

This chapter will discuss the results. A meaning to surveys and data analysis will be interpreted. Evaluations and implications will be debated. Finally, limitations will be an essential step to heighten the got knowledge.

Evaluation

The GPS tracking technology returns the big picture of the walking route and allows us to understand on a map the environment surrounding it. Through this way, specific places and an overall space can be tied to the videos recorded with the eye-tracking technology. Seen buildings and trees can be counted all along the path. The combination of two-dimensions as expressed on big scale maps with three-dimensions as expressed in videos on a detailed scale, becomes a key part of the investigation. Furthermore, the eye-tracking technology can be easily integrated into the GPS tracking.

Initial considerations about video analysis are the following:

- People tend to reach out to other people. That happens specially with the male group. In fact, the category '*people*' gets the most fixation points, that is the most attention, from the male group. On the other hand, the category '*shops*' gets the most of fixation points from the female group. So, the male group is more interested than the female one in interacting with people.

- The category '*parked cars*' gets attention from the participants in almost the same percentage between males and females, with an indifferent/negative grade.

- The categories '*historical buildings*' and '*trees*' get attention points. They are sometimes not remembered.

- Most participants from the female group tend to look at the sky and have high fixation points.

- The senior group tends to look at the ground most of the time.

- In the first part of the walking route, parked cars got more attention than the surrounding shops, trees, and historical buildings.

- The female group is interested in urban art, historical buildings and shops.

According to the survey, 64% of participants consider easy the transition from the road to the pedestrian area, 18% achievable, and 9% safe. Only 9% consider it unsafe. The reason for this overall positive grade could be the presence of a shared space between the end of the road and the pedestrian area, making the transition easy, achievable, and safe.

Another interesting fact is that a test subject did not remember any historical buildings like the state archives or the church while in reality, he did fixate upon those. In other words, his mind did register them. It can be deduced that historical buildings attract attention, meaning fixation points, but then it depends on the participant's background and interests if he or she remembers having seen them.

If we focus on the experiment's hypotheses and consider all participants, we can say that shops get the most fixation points. That does not happen in the case of urban art.

Greenery generally receives positive grades. In particular, 56% of participants found it pleasing to contemplate, and 11% relaxing. 33% did not notice it.

Finally, parked cars give overall negative impressions. In this specific instance, 78% felt indifferent looking at them, and 11% displeasing.

In conclusion, the initial experiment's hypotheses were verified except when talking about urban art. A reason for this could be that there was only one wall with urban art (where the main entrance of the Salling shopping center is). Sometimes, it wasn't even be noticed by participants. That can be a limitation for the investigation.

Evaluation on the method

The site analysis becomes a complete picture when tied with data analysis from the eye tracker. The study site is fully contemplated regarding every aspect.

Using the eye-tracking method allows us to actually map where people put attention to.

The survey helps to understand the grade in which these fixation points are remembered by. For example, parked cars get lots of attention points. However, they get an indifferent or negative grade from the participant.

The eye-tracking method integrated with the other site analyses can be considered as a new dimension: the actual people`s point of view.

When applying it to the urban design field, we could suggest, for example, that knowing that parked cars get (negative) attention, the designer could remove those and push the pedestrian´s attention to other things on the street, like nature or water attractions (which get positive feelings) and thus improving the quality of the street path.

Implications

If we connect the investigation to previous studies, the results of this experiment confirm all found conclusions from the papers we took into consideration. These were:

- Parked cars attract interest.

- People respond to an urban feature unconsciously. This was illustrated when a participant did not remember having seen something, but actually his mind did put attention to it.

- The urban space influences the people`s sense of place in the way that they feel different about distinct street features.

- People remember urban features based on their backgrounds. For example, a participant, who is a professor specialist in international hospitality management and culture and guest relations, was more attracted to people than on other categories in the experiment. Also, another subject who worked in day care, was more interested in children along their walking route.

Finally, we should address the questions formulated in the beginning about implications between imageability theory and the eye-tracking method. Kevin Lynch's theory focuses on the drawing of mental maps based on the five elements of the urban space. This process involves only visual memory, while the eye-tracking method includes the unconscious level of the mind as well. The perception of the space in the latter is total. Both the theory and the technological method can compete with each other when talking about the human perspective: they are the conscious and the unconscious investigation levels.

The *Serial Vision analysis* utilizes pictures to give the sense of place. That can be seen as a first step for the eye-tracking data analysis. Therefore, once the sense of place is initially understood, then the actual elements that receive attention points are detected.

The eye-tracking method discredits these analyses in the way that the last two build a base for the study of an urban space before going further in analyzing the eye-tracking data.

Limitations

This study selected the small sample size of nine participants, including only two seniors within the target group. That doesn't issue generalized results. This aspect needs to be improved in further studies.

Moreover, for an unknown reason, the eye-tracking data from one female senior participant got lost from the Pupil Invisible Companion device after the walking test was carried out. An assumption for that could be that the subject, during the walk, inadvertently touched the world camera attached to the eye-tracking glasses and the recording therefore stopped.

The other limitation was the absence of urban art on the streetscape to be categorized to investigate in the walking route. So, the comparison, supposed by the hypothesis, about frequency of fixation points between shops and urban art as categories, couldn't be tested.

Regarding the technology itself, the Pupil Invisible Glasses (GmbH, 2021) were easy to use and calibration was not need. However, its accuracy is lower than the Tobii Pro Glasses 3 (AB, 2021).

Finally, results did not give back the specific gender needs that were expected. This dissertation hypothesized that it would find inequalities about gender-sensitive planning. This couldn't be proven because only differences between them were found out. Nevertheless, the latter still can be helpful in making considerations when designing urban projects or planning.

Conclusion

This dissertation aimed to test the eye-tracking method when applied to the urban design context through the lens of gender perception of a streetscape. Based on the survey and the eye-tracking data that was carried out, the streetscape has been well-investigated regarding the human perspective. By using this method, we can conclude that the gender perception's differences are individualized and compared in an easy and smart way.

By reading the results we can conclude that the eye-tracking technology can be used as an investigative method of the urban space from a gender perception perspective. As a consequence, it can improve the quality of the city as a whole.

The experimental design methodology was well fitted to the eye-tracking technology test. Furthermore, surveys helped complete the process. Finally, the task was well-structured, enabling a successful classification of all experiments. The approach was effective in achieving its goal.

The study shed interesting light about how males and females perceive a specific streetscape`s features, as well as the different ways they look at people and the different interests that exist between them.

The actual point of people's view becomes a potential new field to investigate when using the eye-tracking method together with common site analyses. Legibility and Serial Vision analyses can be seen as the foundation for eye-tracking analysis.

Finally, despite the limited number of participants, the demographic group was well mixed and met different age and profession criteria in the adult and senior target group frame.

Recommendations for future applications of the eye-tracking method in the investigative field of urban design have come up through this study. They can be summarized as the following:

- Carry out small tasks one at time, given that the method requires data processing. The more amount of data collected, the more time and processor capacity is needed.

- Analyze and evaluate the urban space for the investigation before starting.

- Define the procedure to follow beforehand and prepare extensive surveys and instructions.

- Make a pilot test.

- Explain the research question and what will be inquired in video analyses.

- This method works on a detailed scale of the urban environment. Integrating it with GPS tracking technology can help have scalable sense of place in maps.

The Eye-tracking method used alone is a very general approach to use in the field and has no direct connections to the gender perspective`s investigation. What makes the difference is the integrated use of surveys and the close definition of the research questions or hypotheses. This study helped understand the pedestrian's point of view in a new technological way. The conscious and unconscious participants' perceptions were investigated. The voice of the gender group is being considered and the people took an active part in the urban space's analysis.

Reference list

(EIGE), I. E. d. I. d. G., 2016. *What is gender mainstreaming?*. [Online]
Available at: https://eige.europa.eu/gender-mainstreaming/what-is-gender-mainstreaming

AB, T., 2021. *Tobii pro*. [Online]
Available at: https://www.tobiipro.com/product-listing/tobii-pro-glasses-3/
[Senest hentet eller vist den 13 01 2021].

Collins, 2021. *Collins Dictionary*. [Online]
Available at: https://www.collinsdictionary.com/
[Accessed May 2021].

Cullen, G., 1971. *The Concise Townscape*. s.l.:Oxford ; Boston : Routledge/Architectural Press.

Damyanovic, D., Reinwal, F. & Weikmann, A., 2013. *Manual for Gender Mainstreaming in Urban Planning*. Vienna: Urban Development Vienna.

Duchowski, A. T., 2017. *Eye Tracking Methodology*. 3. red. USA: Springer.

GmbH, P. L., 2021. *pupil-labs.com*. [Online]
Available at: https://pupil-labs.com/products/invisible/
[Accessed April 2021].

Gross, C. G., 1997. Leonardo da Vinci on the Brain and Eye. *The Neuroscientist (Baltimore, Md.)*, 3(5), pp. 347-355.

Hollander, J. B. et al., 2019. Seeing the city: using eye-tracking technology to explore cognitive responses to the built environment. *Journal of Urbanism*, 12(2), pp. 156-171.

Hollander, J. B., Sussman, A., Purdy Levering, A. & Foster-Karim, C., 2020. Using Eye-Tracking to Understand Human Responses to Traditional Neighborhood Designs. *Planning Practice and Research*, 35(5), pp. 485-509.

Hollander, J. & Hollander, J., 2016. Brain responses to architecture and planning: a preliminary neuro-assessment of the pedestrian experience in Boston, Massachusetts. *Architectural Science Review*, 59(6), pp. 474-481.

Kosslyn, S. M., 2005. Mental images and the brain. *Cognitive Neuropsychology,* 22(3-4), pp. 333-347.

Lynch, K., 1964. *The Image of The City*. s.l.:The MIT Press.

Mitsugami, I., Ukita, N. & Kidode, M., 2005. Robot navigation by eye pointing. *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, Årgang 3711 LNCS, pp. 256-267.

Noland, R. B. et al., 2017. Eye-tracking technology, visual preference surveys, and urban design: preliminary evidence of an effective methodology. *Journal of Urbanism*, 10(1), pp. 98-110.

Office, N. C., n.d. [Online]
Available at: https://www.gps.gov/systems/gps/

Planning, U., 2018. Research on perception of objects and spaces. *Czasopismo Techniczne*, Volume 12, pp. 5-22.

Pupil Labs, 2021. *docs.pupil-labs.com*. [Online]
Available at: https://docs.pupil-labs.com/invisible/user-guide/analysis/#pupil-player
[Senest hentet eller vist den April 2021].

QGIS, 2021. *qgis.org*. [Online]
Available at: https://qgis.org/en/site/

Strava, 2021. *Strava.com*. [Online]
Available at: https://www.strava.com/

Sussman, A. & Hollander, J. B., 2015. *Cognitive Architecture : Designing for How We Respond to the Built Environment.* New York: N.Y. : Routledge.

The Language Archive, 2021. *archive.mpi.nl*. [Online]
Available at: https://archive.mpi.nl/tla/elan
[Accessed April 2021].

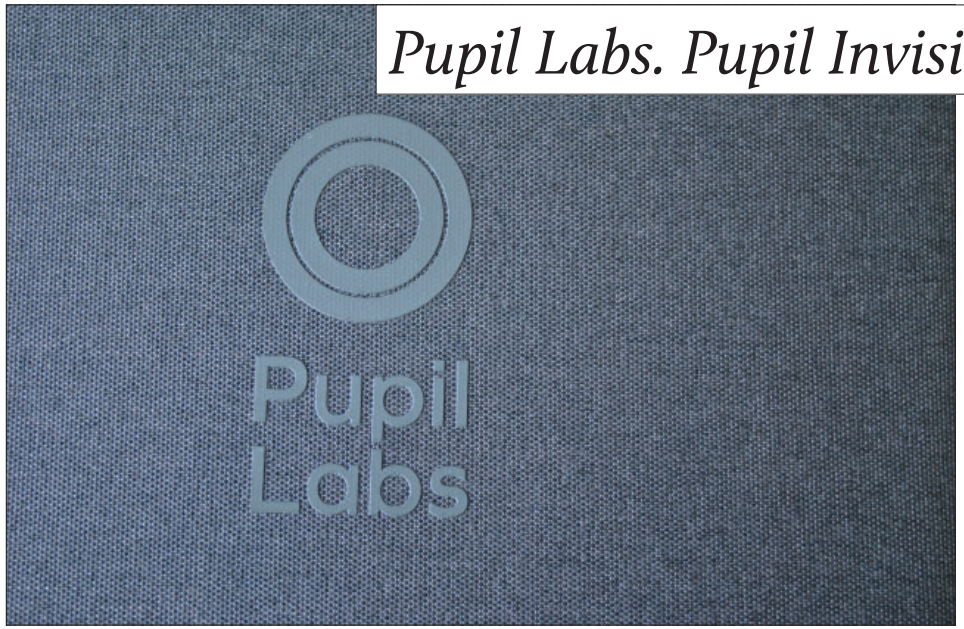
Tobii, 2021. *Tobii Eye Tracker 5*. [Online]
Available at: https://gaming.tobii.com/product/eye-tracker-5/
[Accessed 13 01 2021].

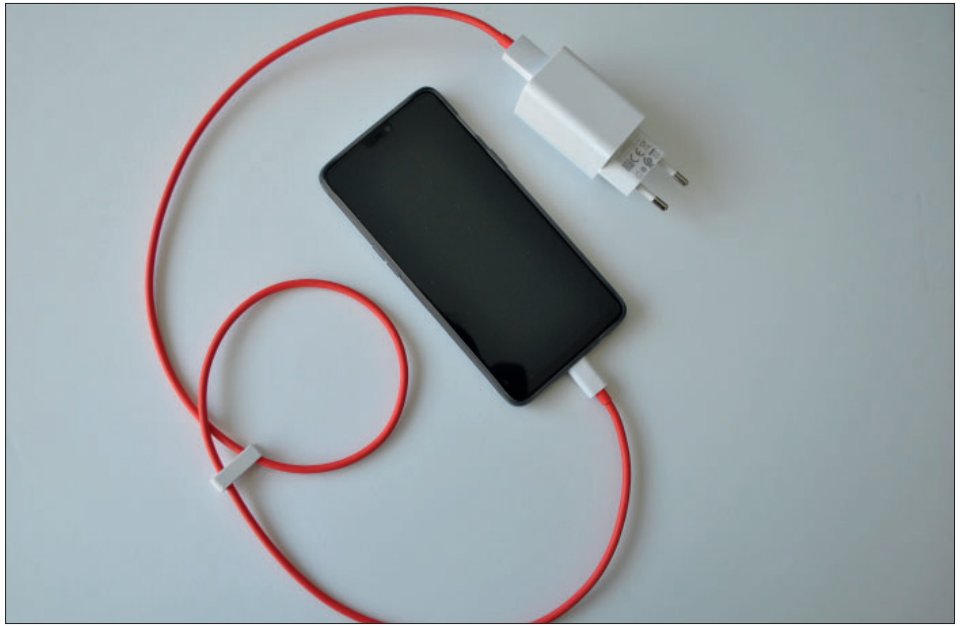
Vainio, T., Jokinen, A., Karppi, I. & Leino, H., 2019. Towards Novel Urban Planning Methods - Using Eye-tracking Systems to Understand Human Attention in Urban Environments. *Conference on Human Factors in Computing Systems* - Proceedings, pp. 1-8.

Zhang, L. M., Zhang, R. X., Jeng, T. S. & Zeng, Z. Y., 2019. Cityscape protection using VR and eye tracking technology. *Journal of Visual Communication and Image Representation*, Årgang 64, p. 102639.

Appendix

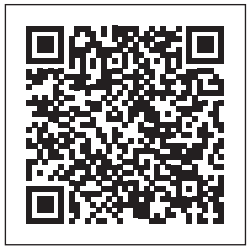
Pupil Labs. Pupil Invisible Eye-tracking Glasses



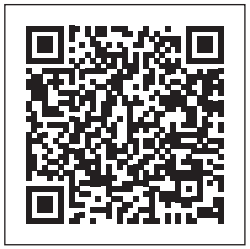



TØJ eksperten

Pupil Invisible Recordings

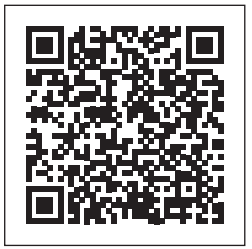


Test 01



Test 02

Test 04



Test 05

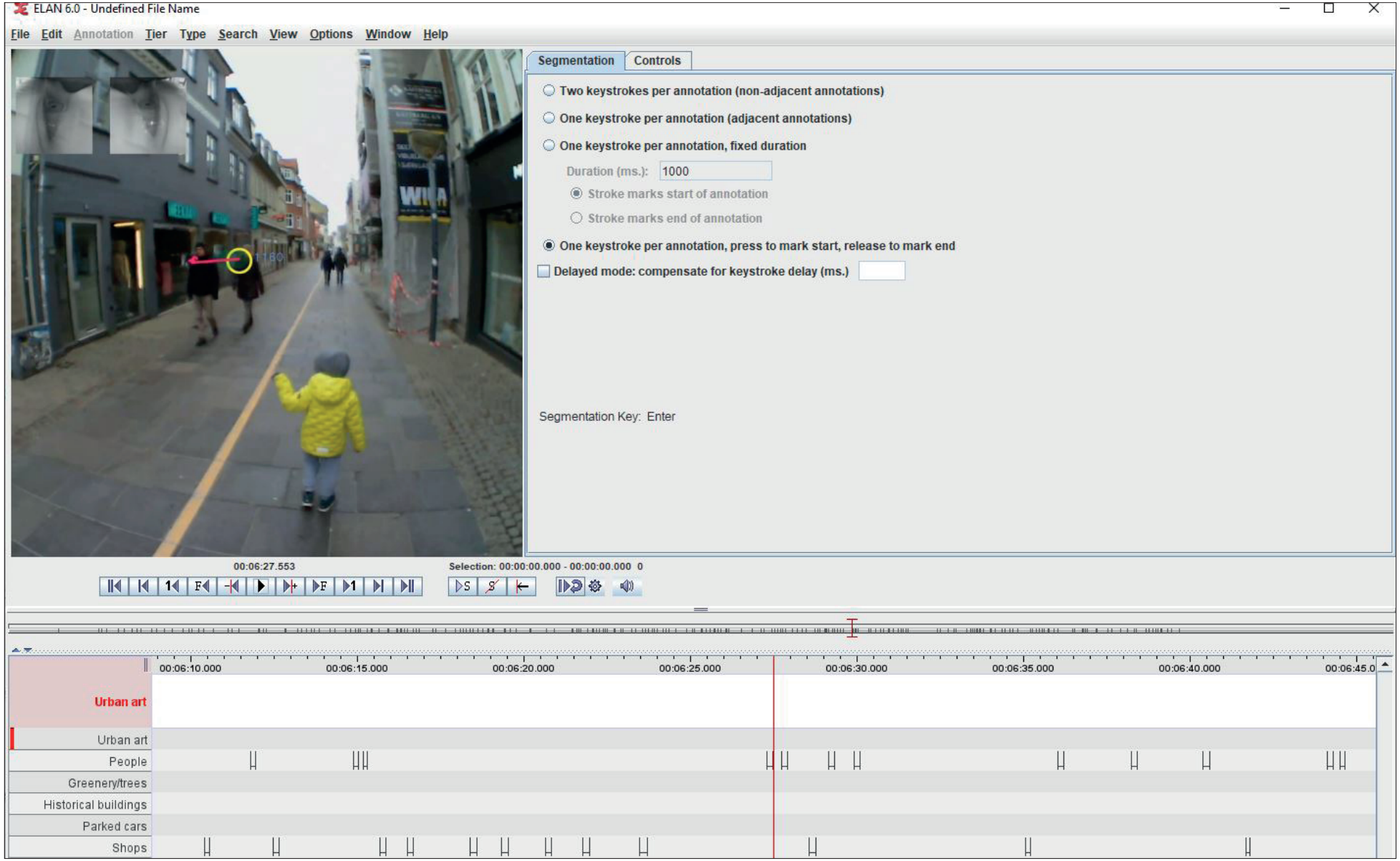
Test 06

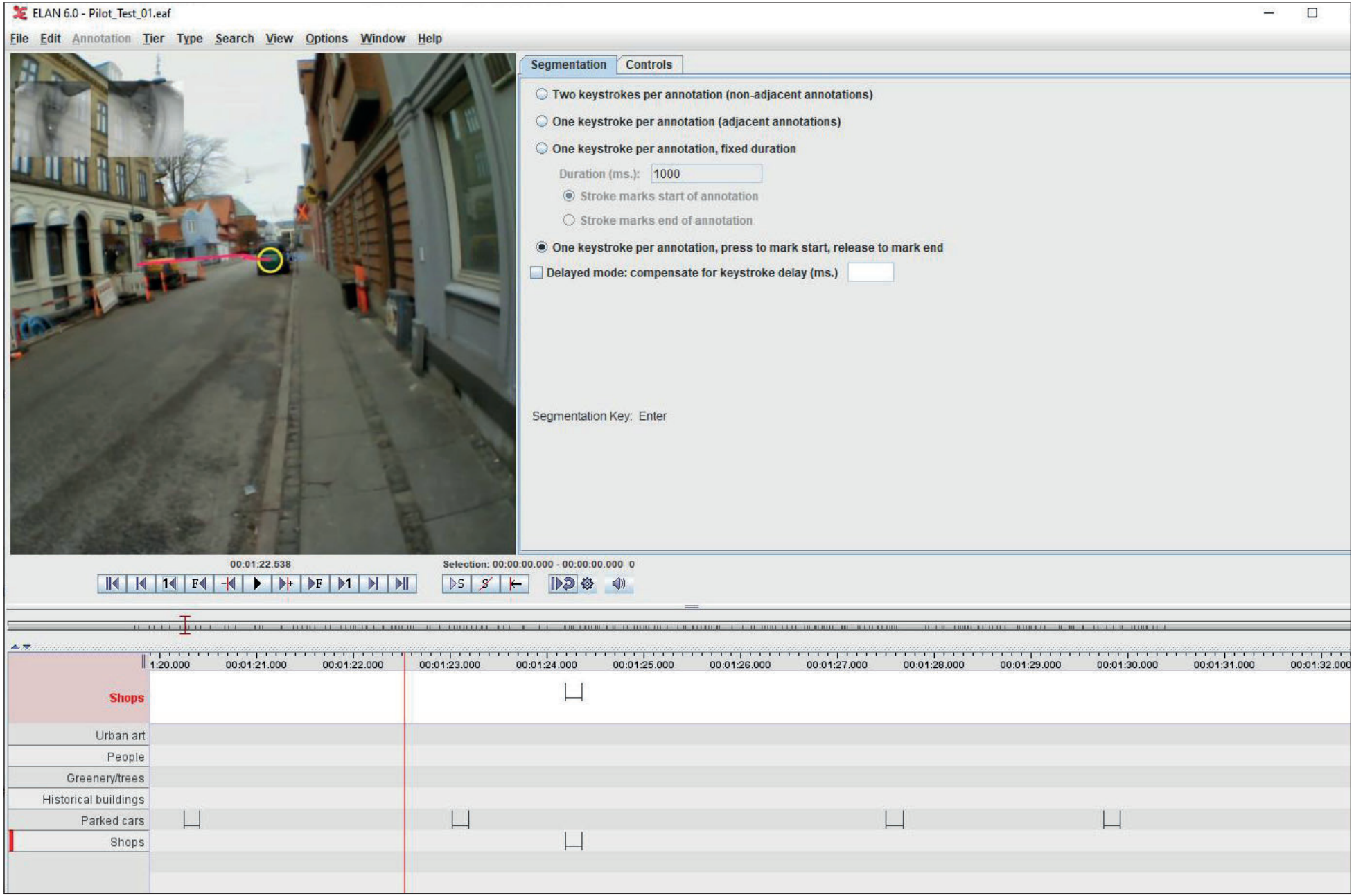
Test 07

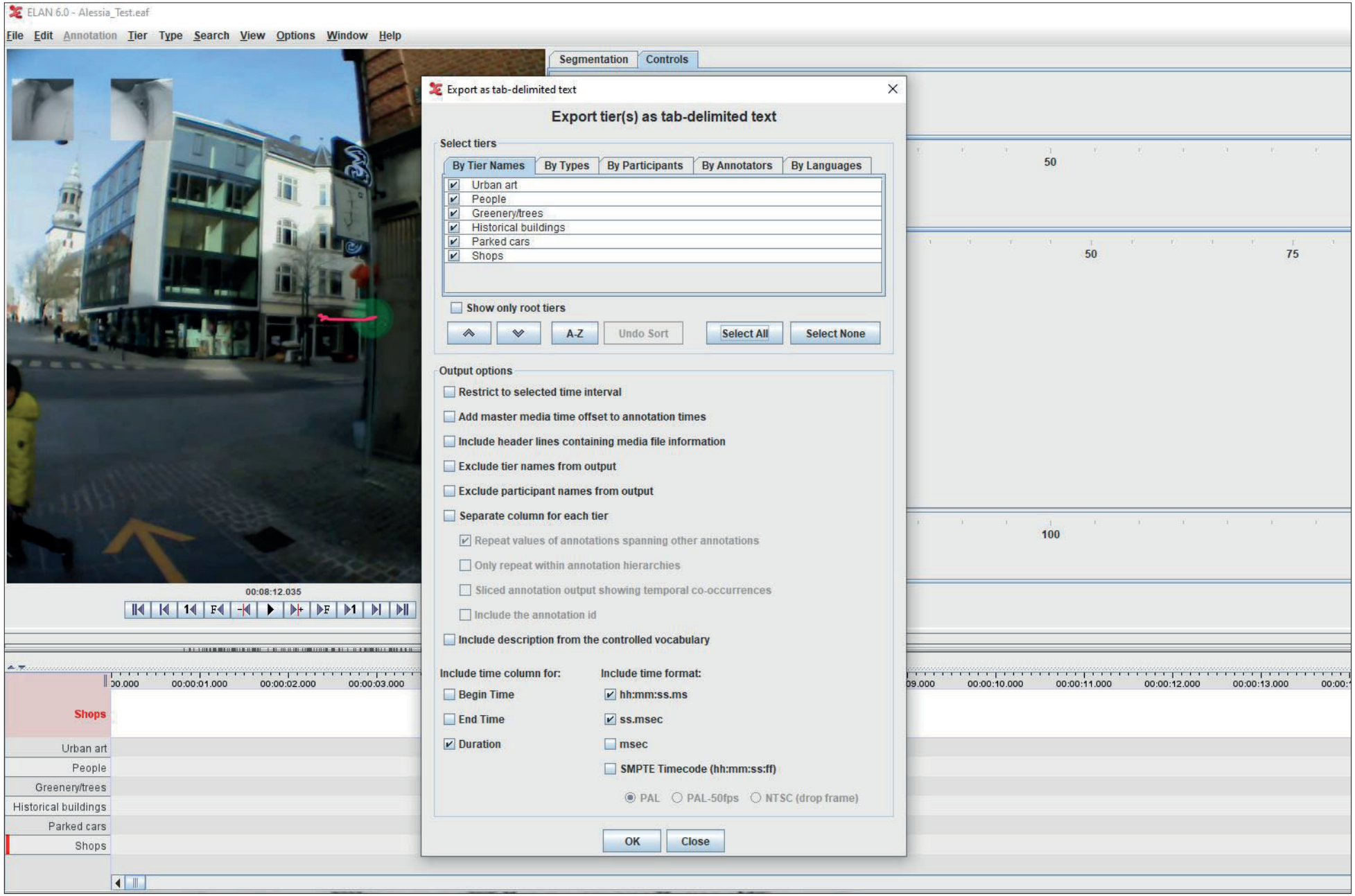
Test 08

Test 09

Video analysis and statistics




ELAN 6.0 - Pilot_Test_01.eaf
File Edit Annotation Tier Type Search View Options Window Help
Segmentation
Controls
Two keystrokes per annotation (non-adjacent annotations)
One keystroke per annotation (adjacent annotations)
One keystroke per annotation, fixed duration
Duration (ms.): 1000
Stroke marks start of annotation
Stroke marks end of annotation
One keystroke per annotation, press to mark start, release to mark end
Delayed mode: compensate for keystroke delay (ms.)
Segmentation Key: Enter
00:01:22.538
Selection: 00:00:00.000 - 00:00:00.000 0
1:20.000
00:01:21.000
00:01:22.000
00:01:23.000
00:01:24.000
00:01:25.000
00:01:26.000
00:01:27.000
00:01:28.000
00:01:29.000
00:01:30.000
00:01:31.000
00:01:32.000
Shops
Urban art
People
Greenery/trees
Historical buildings
Parked cars
Shops


ELAN 6.0 - Alessia_Test.eaf
File Edit Annotation Tier Type Search View Options Window Help
Segmentation Controls
Export as tab-delimited text
Export tier(s) as tab-delimited text
Select tiers
By Tier Names By Types By Participants By Annotators By Languages
Urban art
People
Greenery/trees
Historical buildings
Parked cars
Shops
Show only root tiers
A-Z
Undo Sort
Select All
Select None
Output options
Restrict to selected time interval
Add master media time offset to annotation times
Include header lines containing media file information
Exclude tier names from output
Exclude participant names from output
Separate column for each tier
Repeat values of annotations spanning other annotations
Only repeat within annotation hierarchies
Sliced annotation output showing temporal co-occurrences
Include the annotation id
Include description from the controlled vocabulary
Include time column for:
Begin Time
End Time
Duration
Include time format:
hh:mm:ss.ms
ss.msec
msec
SMPTE Timecode (hh:mm:ss:ff)
PAL PAL-50fps NTSC (drop frame)
OK
Close
00:08:12.035
50
50
75
100
00:00:01.000
00:00:02.000
00:00:03.000
00:00:10.000
00:00:11.000
00:00:12.000
00:00:13.000
Shops
Urban art
People
Greenery/trees
Historical buildings
Parked cars
Shops

Weekend at 9.30 - fewer people along the walking route

Test 01	
Category	Frequency
Urban art	4
People	76
Greenery/trees	10
Historical buildings	13
Parked cars	26
Shops	94

Test 04	
Category	Frequency
Urban art	4
People	36
Greenery/trees	21
Historical buildings	27
Parked cars	11
Shops	147

Test 02 - 03	
tends to look at the ground (most of the time) -	
Category	Frequency
Urban art	4
People	34
Greenery/trees	22
Historical buildings	11
Parked cars	14
Shops	101

Test 05	
sometimes looking at the sky	
Category	Frequency
Urban art	22
People	59
Greenery/trees	8
Historical buildings	13
Parked cars	47
Shops	184

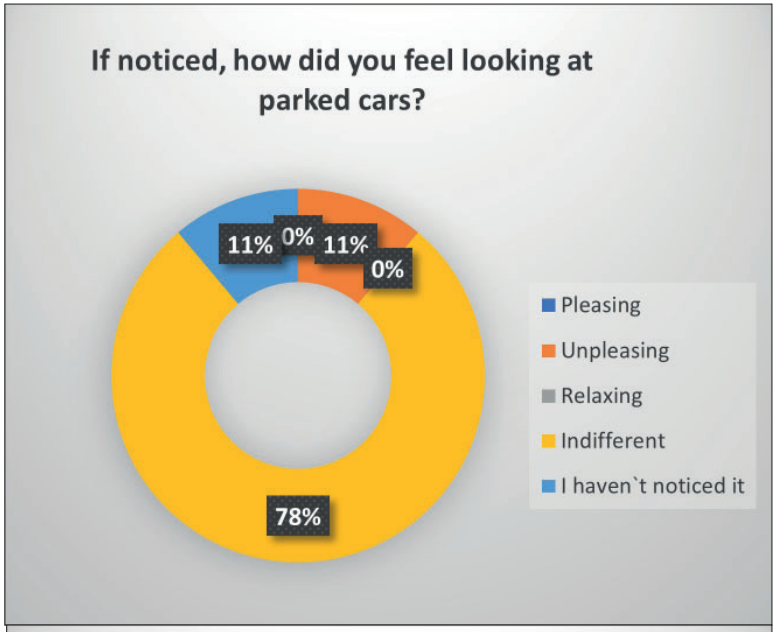
Weekend at 15.30 - more people along the path

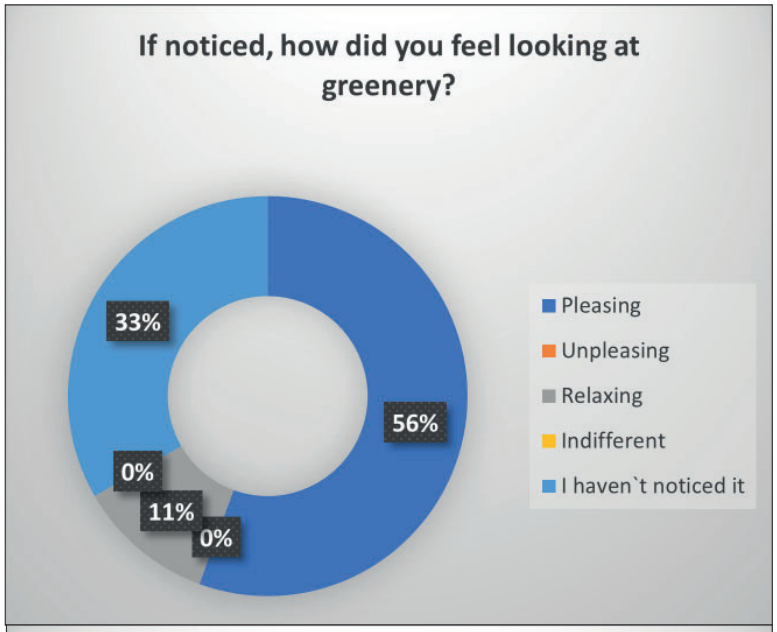
Test 06	
Category	Frequency
Urban art	0
People	145
Greenery/trees	6
Historical buildings	6
Parked cars	24
Shops	62

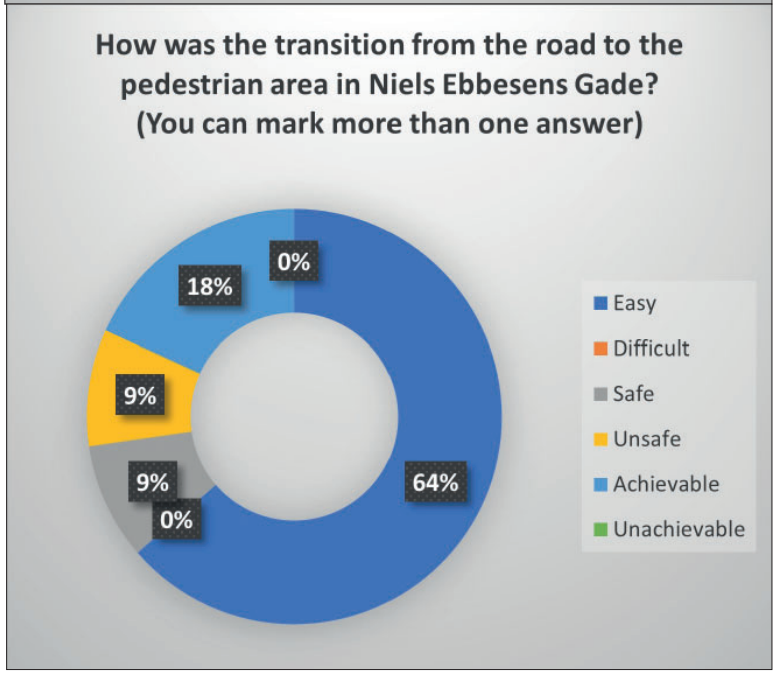
Test 08	
Category	Frequency
Urban art	8
People	63
Greenery/trees	4
Historical buildings	12
Parked cars	12
Shops	103

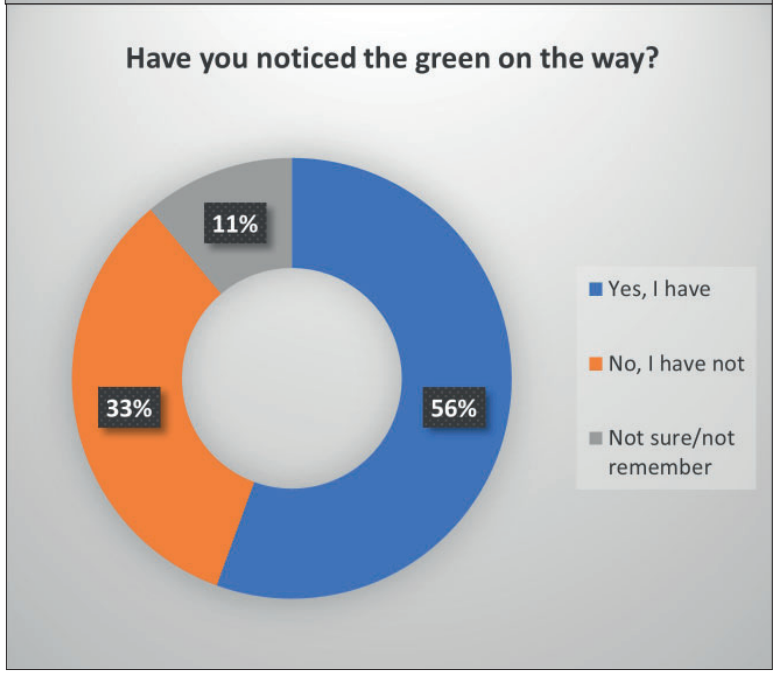
Test 07	
tends to look at the sky - high fixation point	
Category	Frequency
Urban art	0
People	30
Greenery/trees	5
Historical buildings	6
Parked cars	9
Shops	64

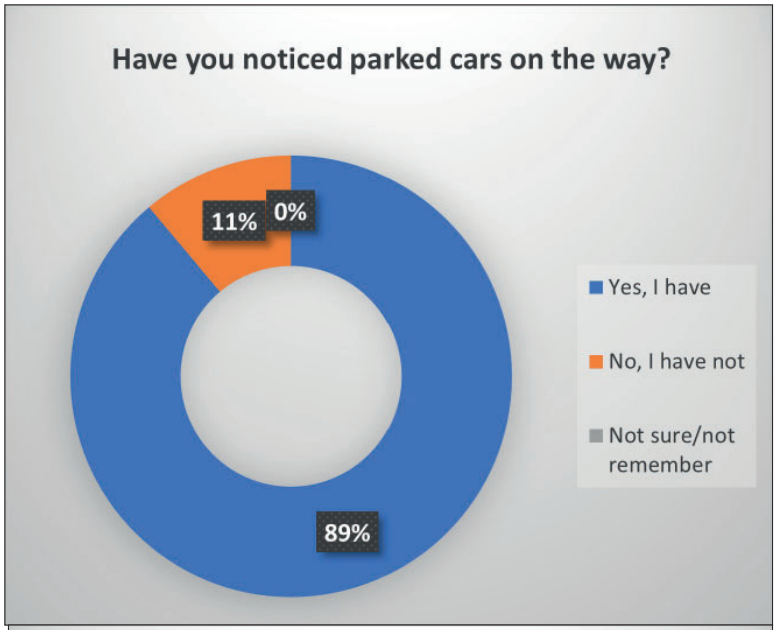
Test 09	
interested in people than shops	
Category	Frequency
Urban art	1
People	146
Greenery/trees	5
Historical buildings	3
Parked cars	11
Shops	91

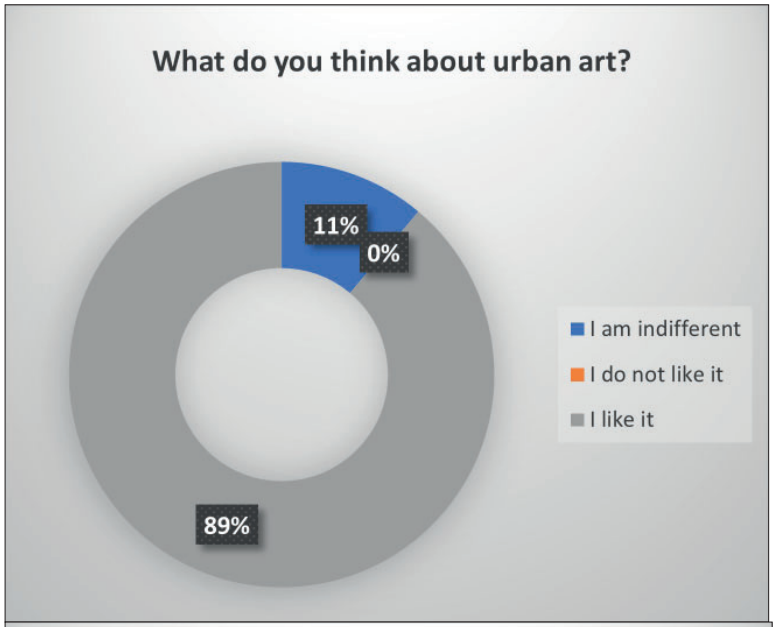

If noticed, how did you feel looking at parked cars?
11%
0%
11%
0%
78%
Pleasing
Unpleasing
Relaxing
Indifferent
I haven`t noticed it

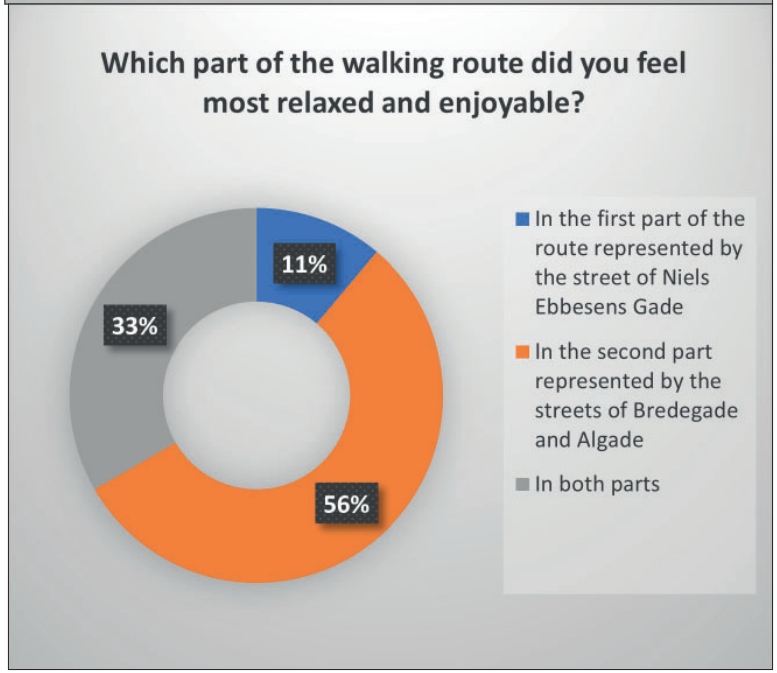

If noticed, how did you feel looking at greenery?
33%
56%
0%
11%
0%
Pleasing
Unpleasing
Relaxing
Indifferent
I haven`t noticed it

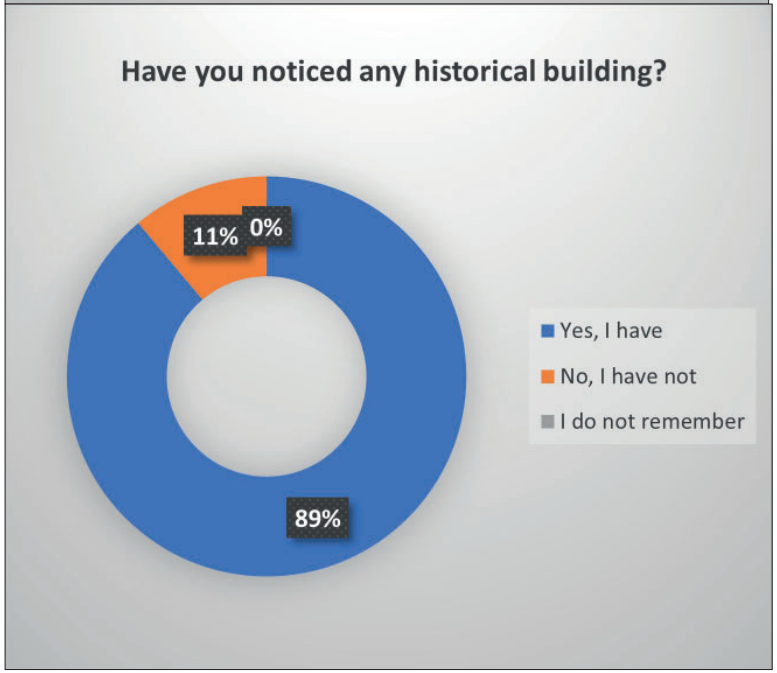

How was the transition from the road to the pedestrian area in Niels Ebbesens Gade? (You can mark more than one answer)
0%
18%
9%
9%
64%
0%
Easy
Difficult
Safe
Unsafe
Achievable
Unachievable

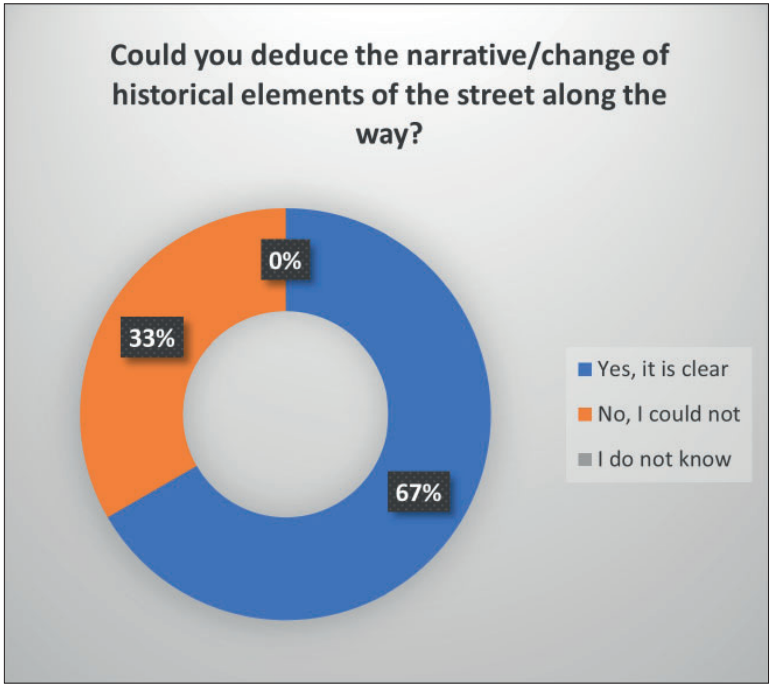

Have you noticed the green on the way?
11%
33%
56%
Yes, I have
No, I have not
Not sure/not remember

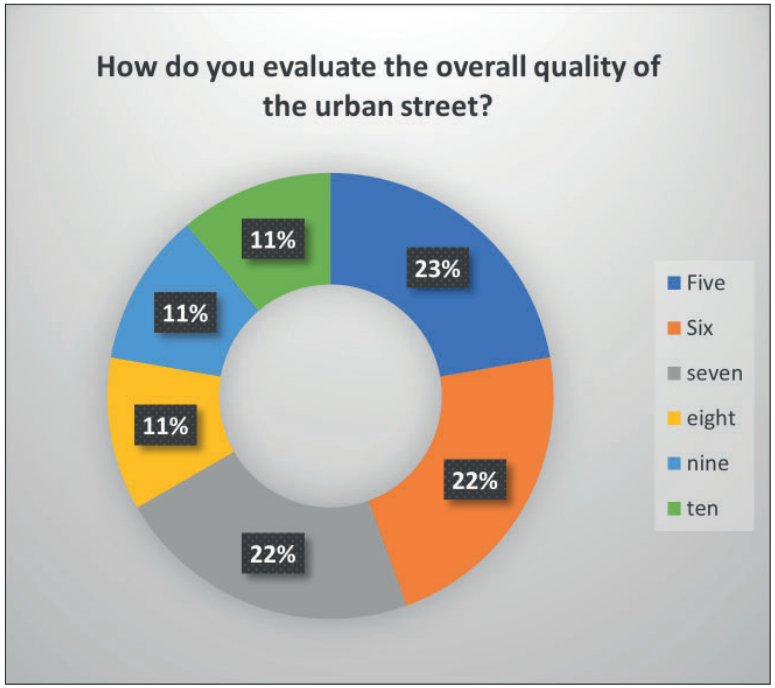

Have you noticed parked cars on the way?
11%
0%
89%
Yes, I have
No, I have not
Not sure/not remember

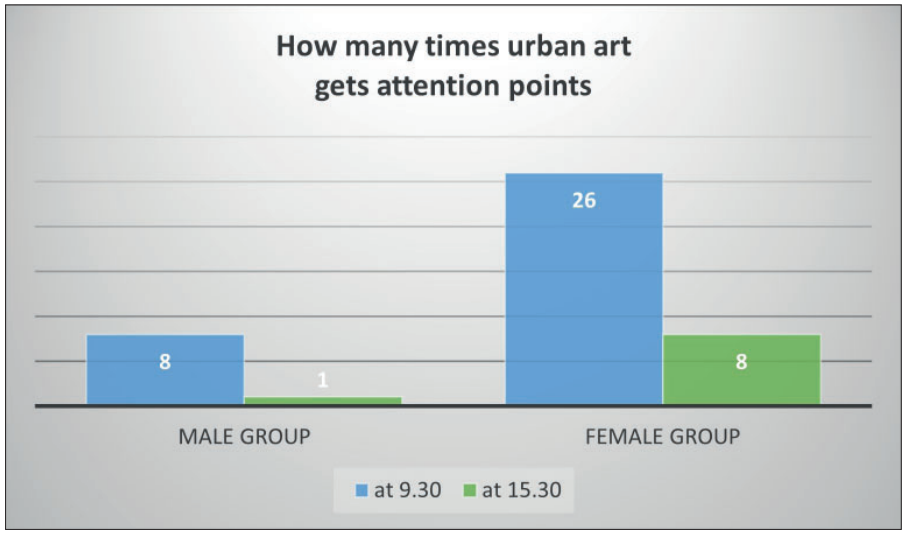

What do you think about urban art?
11%
0%
89%
I am indifferent
I do not like it
I like it

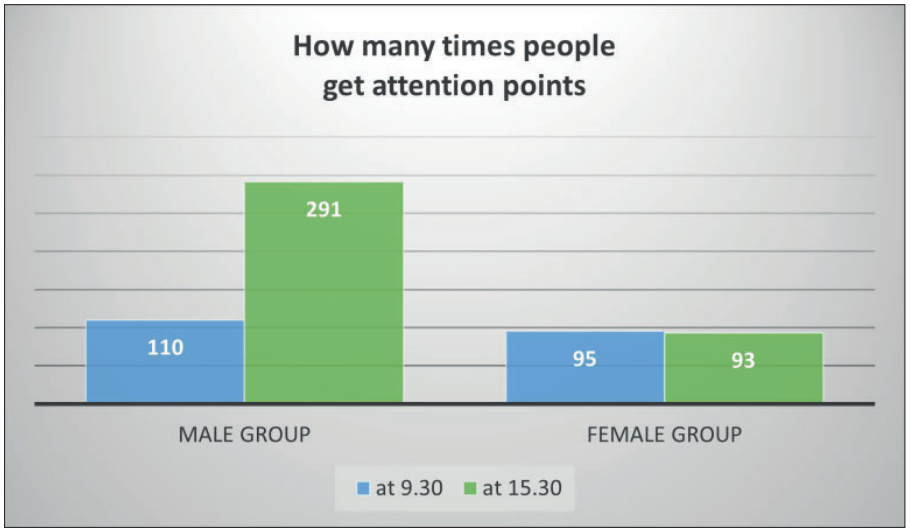

Which part of the walking route did you feel most relaxed and enjoyable?
11%
33%
56%
In the first part of the route represented by the street of Niels Ebbesens Gade
In the second part represented by the streets of Bredegade and Algade
In both parts

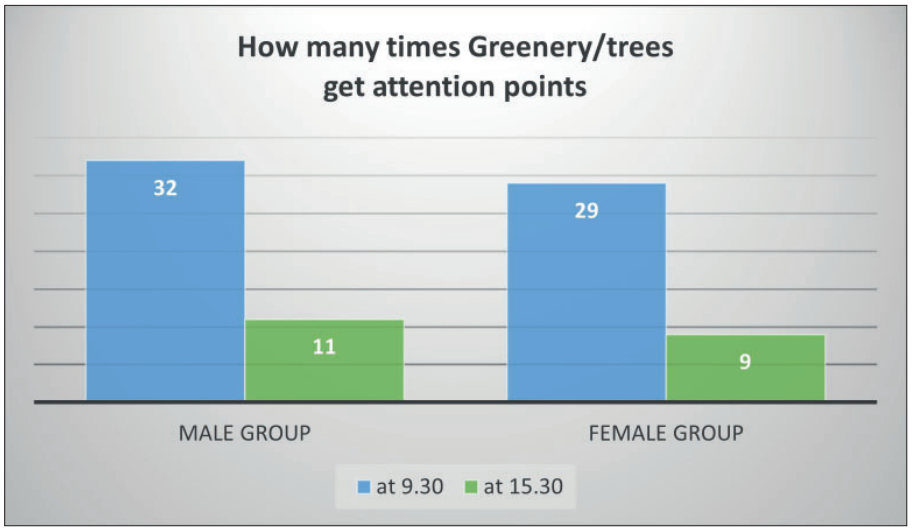

Have you noticed any historical building?
11%
0%
89%
Yes, I have
No, I have not
I do not remember

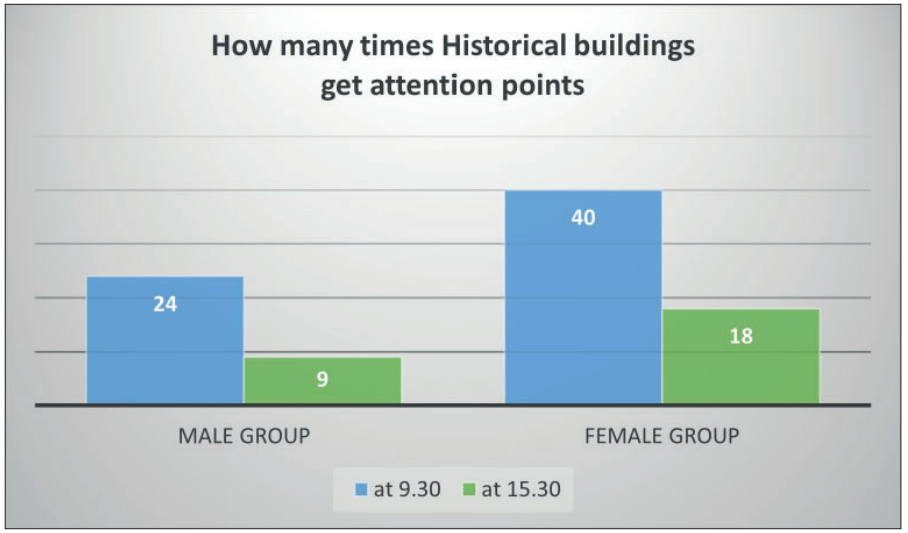

Could you deduce the narrative/change of historical elements of the street along the way?
0%
33%
67%
Yes, it is clear
No, I could not
I do not know

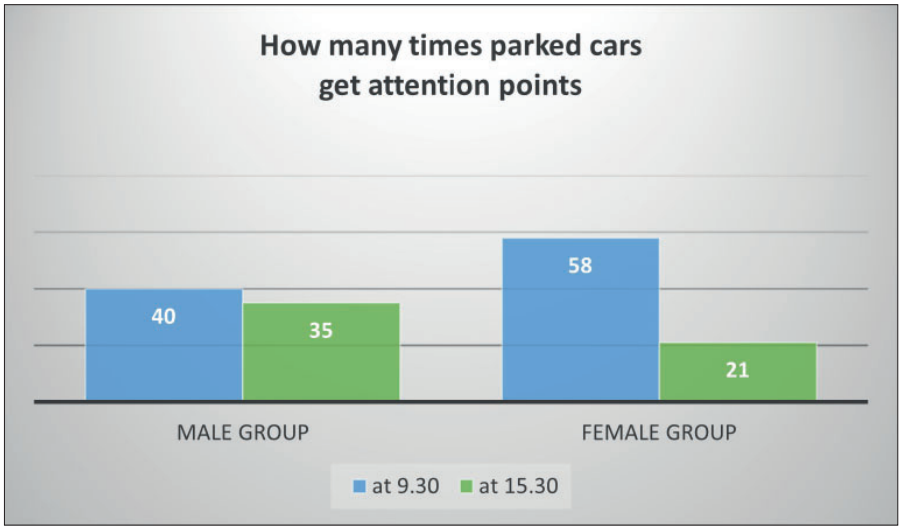

How do you evaluate the overall quality of the urban street?
23%
22%
22%
11%
11%
11%
Five
Six
seven
eight
nine
ten

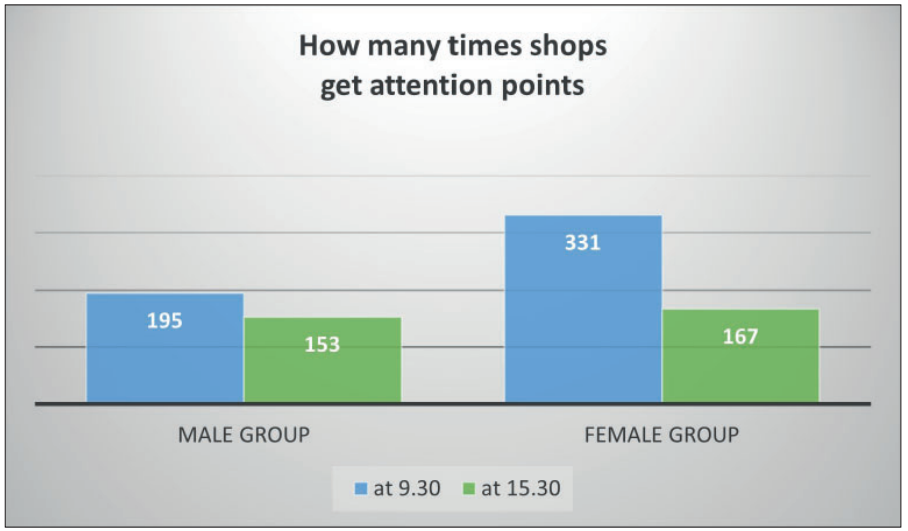

How many times urban art gets attention points
8
1
26
8
MALE GROUP
FEMALE GROUP
at 9.30
at 15.30

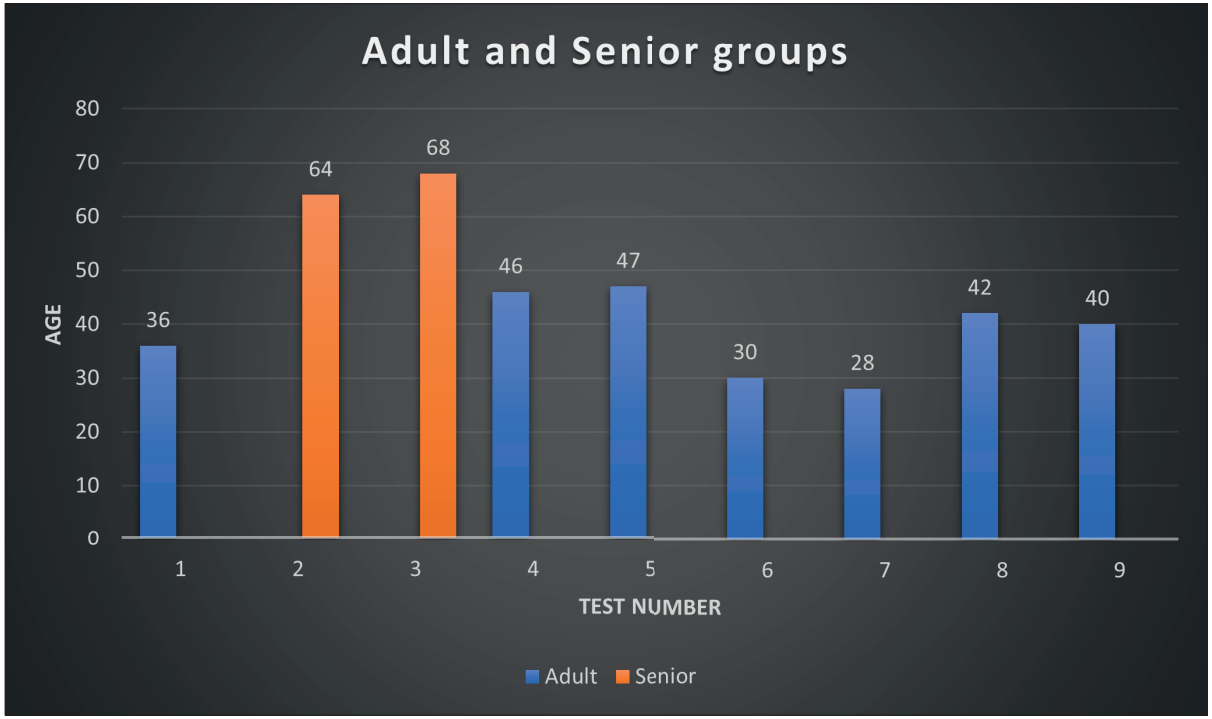

How many times people get attention points
110
291
95
93
MALE GROUP
FEMALE GROUP
at 9.30
at 15.30


How many times Greenery/trees get attention points
32
11
29
9
MALE GROUP
FEMALE GROUP
at 9.30
at 15.30


How many times Historical buildings get attention points
24
9
40
18
MALE GROUP
FEMALE GROUP
at 9.30
at 15.30


How many times parked cars get attention points
40
35
58
21
MALE GROUP
FEMALE GROUP
at 9.30
at 15.30


How many times shops get attention points
195
153
331
167
MALE GROUP
FEMALE GROUP
at 9.30
at 15.30


Adult and Senior groups
80
70
60
50
40
30
20
10
0
AGE
36
64
68
46
47
30
28
42
40
1
2
3
4
5
6
7
8
9
TEST NUMBER
Adult
Senior


PROFILOPTIK
BY SYNSAM
STRØMPER
Phone Fix
Nibe
FESTIVAL