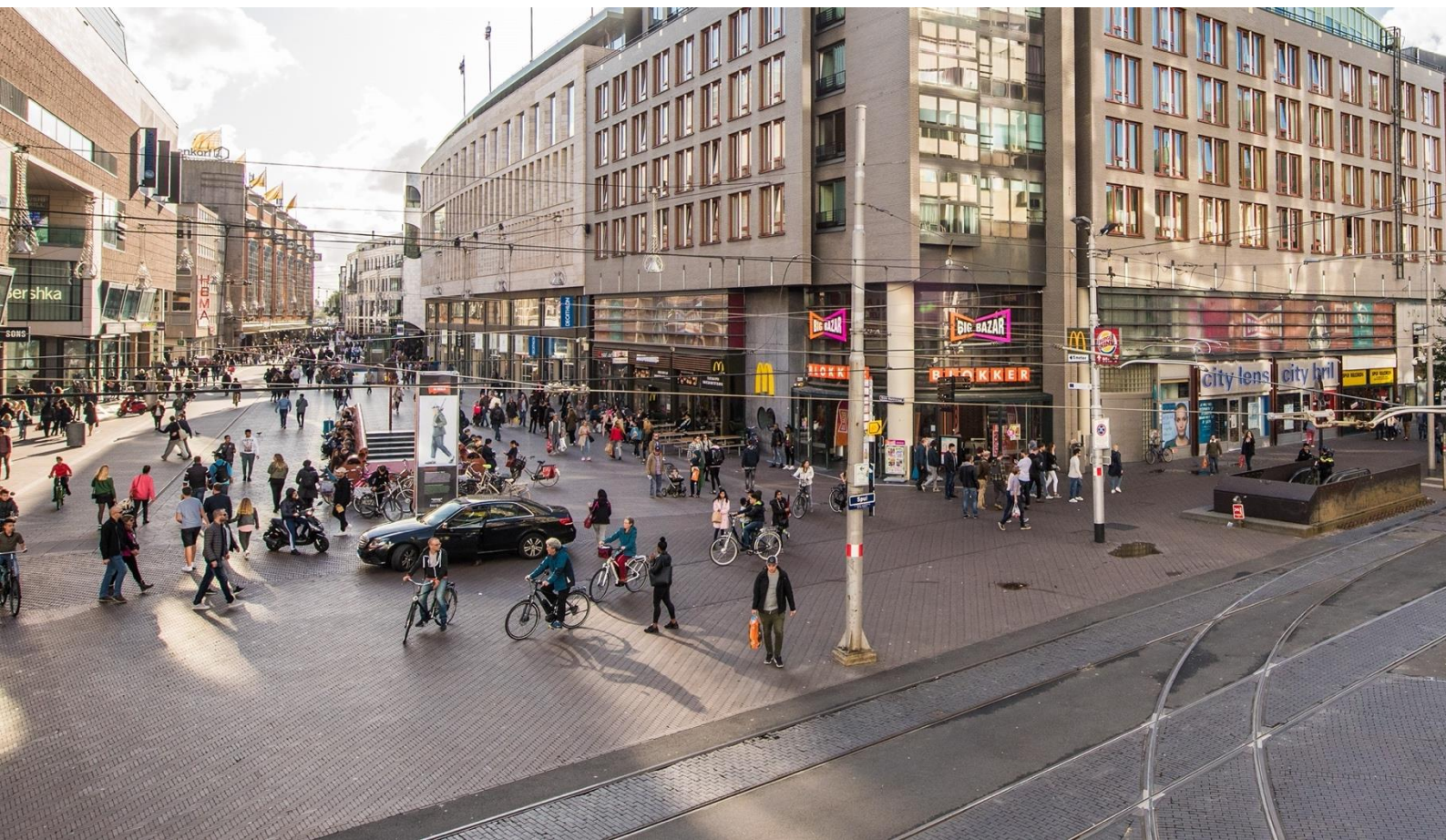


Stress and the city

*A qualitative approach towards urban stressors in
The Hague's city center*



**Universiteit
Utrecht**

Master Thesis

Marc van der Burg
Urban and Economic Geography
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Stress and the city

A qualitative approach towards urban stressors in the Hague's city center

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Just a daily commute in the big city

Today is shaping up to be a vibrant day as I head out for work in the city. Opting for the metro and train combo, I soon find myself amidst the morning rush, standing among fellow commuters packed into the train car. It's a familiar scene during peak hours, and while it's a bit crowded, I figure I can manage the final leg of my journey on foot, taking advantage of the opportunity for a brisk walk.

Stepping off at The Hague Holland Spoor station, I narrowly avoid a tram speeding by – a reminder to stay vigilant in urban settings. Deciding on my route, I opt for a quieter path through the neighborhood, sidestepping the congestion and noise of the main thoroughfare.

As I walk through the Huygenspark, I find solace in the tranquil surroundings, admiring the greenery and sharing smiles with fellow park-goers enjoying their morning walks with their canine companions.

Glancing at my watch, I realize I need to pick up the pace to make it to my 9 o'clock appointment on time. Though tempted by a seemingly faster route, I opt for safety, avoiding an area rumored to have recent incidents. As I near my workplace, the city's hustle and bustle intensifies, with impatient drivers and lengthy traffic light waits. Nonetheless, I arrive just in the nick of time, reflecting on the benefits of my morning walk – from burning calories to clear my mind and sometimes enjoying the fresh air amidst the tense urban landscape.

Preface

Dear reader,

Before you lies my thesis on urban stressors, the culmination of my Master's in Urban and Economic Geography at Utrecht University. Pursuing this study part-time alongside a full-time job and other life obligations was a challenging yet enriching experience, fostering both knowledge and skills development.

The subject of urban stressors initially captured my attention during my daily commutes in the city, prompting questions about their impact on the human mind. As a policy advisor in mobility, I observed governments' strong emphasis on transitioning from car usage to walking and cycling. This led me to ponder whether we might inadvertently be creating new challenges. Amidst all the activity in cities, what are the implications for pedestrians' mental health? Departing from my usual quantitative research approach, I opted for a qualitative methodology to delve deeper into this intriguing topic, particularly in the realm of environmental psychology and healthcare-related stress.

I extend my heartfelt gratitude to all those who supported me on this research journey, including my friends, family, and colleagues. Special thanks to my wife, Valerie, for her unwavering support and patience in listening to my musings and theories about stress and urban environments. Additionally, I express my appreciation to my supervisor, Dr. Elisa Fiore, for her clear communication, positivity, and genuine interest in my work.

It is my hope that the interdisciplinary approach adopted in this thesis will foster collaboration in addressing the complex challenges of creating healthy and sustainable urban environments, ultimately contributing to informed policymaking. I trust that you will find this thesis enjoyable and inspiring, motivating you to pursue impactful endeavors for society.

Warm regards,

Marc van der Burg

Abstract

Background: As urban populations continue to grow, dense urban environments have become characteristic of modern cities. City planners are increasingly seeking sustainable solutions to preserve livability. Policies promoting active modes of travel, such as walking and cycling, aim to foster an active lifestyle and reduce pollution. The COVID-19 pandemic has prompted reconsideration of travel behaviors, raising questions about commuting to work. Urban environments are associated with higher levels of stress and mental health issues compared to rural areas. The objective of this research was to describe and explain insights on walking commuting stress due to the urban environment, to cope with rising levels of urbanization, and a higher level of stress prevalence in this areas together with policies that promote an active way of commuting.

Methods: 14 Participants (7 male and 7 female) were invited to join a walk-along research during the commute in the morning rush hour, evening rush hour, and during an off-peak moment in the afternoon. The participants could choose their routes freely and express their thoughts about their environmental experiences during their walks. All the walk-alongs were recorded with a GoPro Hero11 Black video camera. The study took place in the central area of The Hague, a highly dense urban area with around 11.000 people per square kilometer. Content analysis was performed using NVIVO 14 software. A blend of deductive and inductive reasoning was used to derive categories and new subcategories from the data.

Results: The main findings of the research reveal various spatial tensions that induced stress among the participants, particularly in shared space areas. These spatial tensions comprise a complex interplay between different social and urban design factors. These factors were unclear design relating to illegible design, less space for the pedestrian, and 'claiming behavior between users' relating to territoriality causing crowding. The combination of these factors exacerbated the stress experience. Vigilance was an important emotional expression that was often mentioned, which in the long run can contribute to stress and exhaustion. The coping mechanisms exhibited by the participants could be categorized into problem-focused coping, emotional-focused coping, and future-oriented coping. Natural environments, quiet places with less traffic, places with 'hustle-and-bustle' and a clear urban design were mentioned as stress relieving factors.

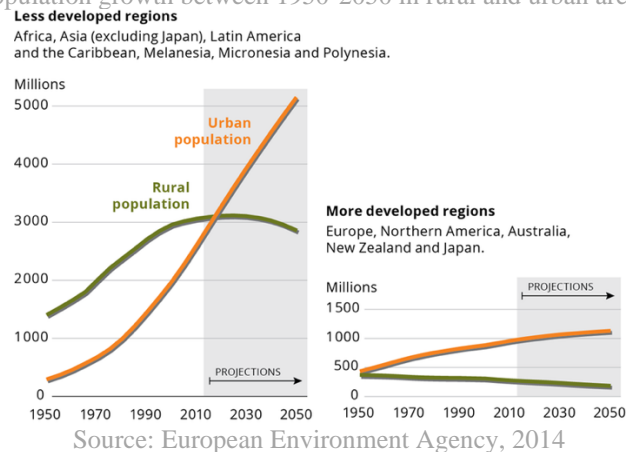
Conclusions: Relatively little research on the effect of multiple stressors in urban environments and how they may interact has been done. The findings of this research are mostly in line with the literature and specifically add insights into how multiple stressors interact with each other, namely the interplay between an unclear design, less space, and the territorial behavior of users. Future studies could explore how environmental stressors interact with other stressors induced by work or home situations, particularly for vulnerable groups like highly sensitive individuals. Integrating quantitative surveys with biotechnical measurements could substantiate the findings of this research.

Keywords: environmental stressors, highly dense urban environment, walk-along interview, coping mechanisms

1. Introduction

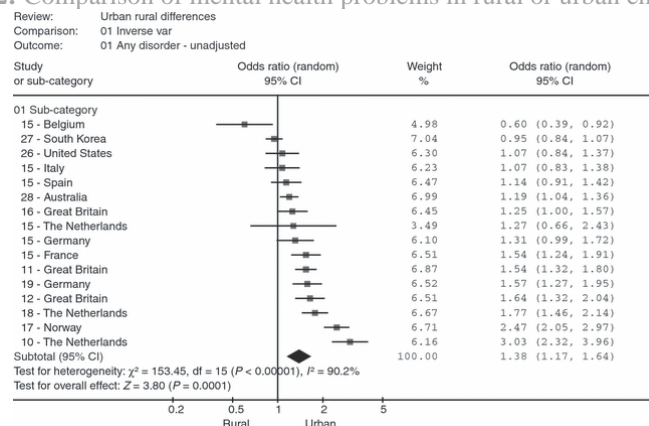
Cities are becoming increasingly populated, and as a result, highly dense urban environments are becoming a common feature of modern cities (see figure 1). With rapid urbanization, city planners seek sustainable solutions to maintain livability in cities. Different policies aim towards more active ways of travel, such as cycling and walking to promote an active lifestyle and create more livable cities with more space and less pollution (Mindell, 2018). With the COVID-19 pandemic seemingly behind us, restrictions such as working at home and social distancing have highlighted the debate on how and if one should travel to work. The promotion of active travel modes, and therefore an expected growth of these modalities on one hand, together with population growth on the other hand could bring new challenges from another perspective.

Figure 1: Population growth between 1950-2050 in rural and urban areas (projected)



While urban environments offer many benefits such as job opportunities, access to public services and cultural activities, they can also be a source of stress for residents and visitors. According to the World Health Organization (2018), mental illness is increasing worldwide, and evidence indicates a higher prevalence of stress in urban environments in comparison with rural environments. A growing body of literature confirms that urban areas have a higher prevalence of mental health problems (Peen et al., 2020; Johansson et al., 2011; Adli, 2011; Heinz et al., 2013; Hosang, 2016). Figure 2 shows the outcome of a study focusing on mental health problems in rural and urban areas in different countries. Urban areas in the countries show a higher prevalence of mental health problems.

Figure 2: Comparison of mental health problems in rural or urban environments



Source: Peen et al., 2010

In recent years, the impact of stress on people's mental and physical health has received increased attention from researchers, policymakers, and urban planners. Research has shown, that within urban

environments, people are surrounded by many stimuli that demand directed attention (i.e. traffic lights, noise, congestion, (over)crowding, air pollution). Spending time in such environments can result in fatigue, which urges the need for people to recover (Kaplan, 1989).

1.1 Objective & research question

This study used qualitative 'walk-along research', supported by video-recording to explore how people experience stress during their walking commute in a high-density urban environment. The research took place in the most highly dense city in the Netherlands, with around 6827 inhabitants per km²: The Hague (CBS, 2023).

This study did not focus on the experience of stress that arises from natural disasters such as floods, hurricanes, earthquakes, or extreme droughts. The objective is to describe and explain insights on walking commuting stress due to the urban environment, to cope with rising levels of urbanization together with policies that promote an active way of commuting. To achieve this goal, the following main research question is conducted:

How do different factors in a high-density urban environment affect momentary stress-related sensations of people on their walking commute to work?

The following sub-questions support the main research question:

- a) *Which environmental stressors can be identified during the Participants' walking commute to work?*
- b) *How do coping mechanisms play a role in dealing with stress during the Participants' walking commute to work?*
- c) *Which individual differences of Participants play a role in the perception of stressors and coping mechanisms?*

1.2 Scientific relevance

The scientific relevance of this thesis lies in its contribution to the field of urban planning and public health. By exploring stress factors in highly dense urban environments, this thesis provides valuable insights into ways urban environments can be designed to promote residents' health and well-being. In a broader sense, public policies aim to improve the welfare of a population. In transport policy, welfare has traditionally been assessed by considering the objective impacts of the transport systems, such as costs, crashes, and environmental degradation (Chatterjee et al., 2019). The subjective experience of transport, including how it contributes to overall well-being is of growing interest (Mokhtarian, 2019). This thesis has a geographical approach and touches upon (environmental) psychology, which can have implications for a wide range of scientific disciplines, including psychology, public health, urban planning, environmental science, and social sciences. The interdisciplinary approach taken in this thesis can help bridge gaps between these fields and foster collaboration in addressing complex challenges of creating healthy and sustainable urban environments.

1.2.1 Scientific gap

When reviewing an abundance of studies focusing on the relationship between, commuting, stress and walking, recommendations for further research have different possible starting points. Some studies state that there is relatively little research on the effect of multiple stressors in urban environments, and how they may interact. Furthermore, the evidence of these studies was limited, and not consistent (Tzivian et al., 2015) and mostly done in a lab (Wang et al., 2016). More research within this area could help to better understand human experiences in the built environment and to design and manage healthy urban environments (Dupere & Perkins, 2007). Marquart et al. (2021), mention that perceived exposure to environmental stressors is often measured with quantitative measures such as closed surveys or (bio-)sensors. Bio-sensors could be used to measure heart rate variability, a biomarker for stress levels. However, research by Huang et al. (2013), showed that exceeding thresholds effects of certain environmental stressors (noise, air pollution) only had a mild effect on HRV which makes it hard to draw valid conclusions. Furthermore, there is little research that

addresses commuters' experiences and perceived stressors *on-site*, which could give in-depth insight into the commuters' related behavior. Sherif Samir Elrafie et al. (2023), recommend focusing on contextual factors that might influence one's rating of the momentary perception of stress at the time of administration. To round off, it is advised that further research may focus on developing and testing *theories of stress* to generate a better understanding of when and how environmental stress may occur and for whom. The possible future research directions, as mentioned above are taken into account in this research to contribute to this scientific need.

1.3 Societal relevance

The economic costs of stress are enormous. In the European Union, overall costs associated with mental health problems have been estimated to be as high as 4% of the GDP or EUR 600 billion over 28 EU countries (OECD, 2018). Stress can lead to a range of negative health outcomes, including depression, anxiety, cardiovascular disease, and obesity. To be more precise, different literature suggests that psychiatric disorders including schizophrenia and anxiety disorders are commonly more prevalent in urban environments (Peen et al. 2010; Lederbogen et al. 2011). A definite causal relationship is still difficult to establish given the complex mechanisms underlying this relation. Given the potential negative impacts of stress on the health and well-being of city dwellers, it is important to understand the stress factors that exist in highly dense urban environments and how they can be mitigated. This thesis explores stress factors in highly dense urban environments to promote well-being among residents and visitors. By doing so, this research can contribute to ensure city dwellers can live healthy and fulfilling lives. By getting more insight into stress factors and therefore promoting well-being, this thesis can help to create more inclusive and engaged cities. Lastly, this thesis can inform policymakers and urban planners about ways to create more supportive and sustainable urban environments.

2. Review and theoretical framework

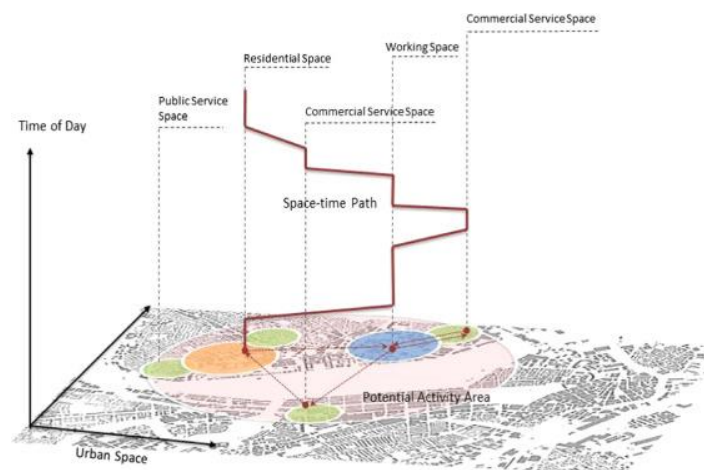
This chapter provides the theoretical framework for this thesis and starts with describing an objective dimension via time-space geography (Hägerstrand, 1973) followed by a description of the subjective dimension with a thorough review of the literature on stress theories and known environmental stressors. The chapter ends by combining the literature research into a conceptual model.

2.1 An objective path through time and space

This study focuses on walking individuals through highly dense urban environments and the stress that arises during that journey. To give a clear frame in which this journey takes place, the theory of time-space geography is used. This section briefly describes the theory of time-space geography and discusses the shortcomings and critiques of the theory.

Swedish geographer Hägerstrand (1973) laid the foundation for what is called time-space geography. This theory assumes that individuals, other organisms, and material objects form paths through two dimensions, namely: (1) time and (2) space. Time is about the amount of time it takes to travel to a certain area (which is highly affected by the modality someone chooses) or the amount of time one stays at a specific location (such as work, home, or school location). Space is about the distance between different points, but also the space different objects take. Figure 3 shows a visual representation of the time-space theory, showing different stops (points) and routes (lines) in time (Y-axis) and space (X-axis) plotted on a map. The map also shows the 'potential activity area', or the 'daily potential path area', which relates to the maximum amount of distance one can reach with a certain modality (car, public transit, walking, or cycling).

Figure 3: Time-space Geography (Hägerstrand, 1973)



Source: <https://www-sciencedirect-com.proxy.library.uu.nl/science/article/pii/S2095263515000722>

The time-space dimensions are the most important pillars of this theory and are complemented by a third pillar, focusing on the identity of the individual. Identity is bound to three other constraints, namely: capability, coupling, and authority constraints. Capability constraints are about the needs for sleep, eating or speed of vehicles or a person. Coupling constraints are bound to the roles someone has, someone has to work or care for the kids. Authority constraints are rules conducted by different institutes, such as the coronavirus restrictions (1,5m distance or staying at home). One can only be in one place during one moment in time and therefore is constrained to time, therefore the constraints can force individuals to make decisions that are bound to their capabilities, obligations, or authority restrictions (for example from their employer or government restrictions). The theory gives a clear frame about time, space, and possible constraints but this theory focuses much on the limitations, and not much on what a person can do or what a person experiences throughout their journey. Giddens (1984), was critical of this theory because, according to him, the constraints and the social context could change, and therefore the model of Hägerstrand is static in a way. Rose (1993) and Creswell

(2006), state that within time-geography, an individual is approached as a neutral object, not taking into account embodied experiences, such as stress. During a trip someone can change according to the experience someone has that arises from the environment. To add a subjective, and embodied experience dimension, the time-space theory, and in particular the identity pillar needs to be enriched with insights from environmental psychology.

2.2 A subjective dimension through time and space

To enrich the theory of time-space geography, the first section discusses different conceptualizations of stress that emerged and developed throughout the last decades. The second section discusses different environmental stressors and factors according to contemporary literature. This chapter ends with a decision for a specific conceptual model based on this literature review.

2.2.1 Abundance of stress theories

Numerous theoretical models have attempted to explain the complex etiology of the phenomenon of psychological stress (Biggs et al., 2017). These theoretical explanations can be categorized according to their conceptualization of stress experience: stress as an external stimulus (emanating from catastrophic events, major life events, or chronic circumstances), stress as a response (physiological or psychological), stress as a process differing in individual/environmental interaction (Cox and Griffiths et al., 2010). Table 1 shows a variety of stress theories over the last decades, their founder, year a short explanation, and the category divided in stress as a response and stress as an external stimulus.

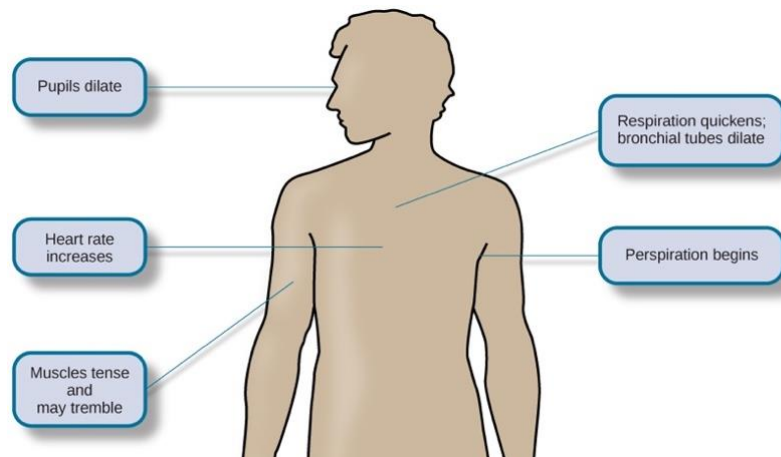
Table 1: Different stress theories

Theory name	Founder	Year	Explanation	Category
Arousal Theory	Yerkes-Dodson	1908	Proposes that there is an optimum level of arousal under which people perform best.	Stress as a response
Acute and chronic stress	Cannon	1930	Acute stress is described as a fight or flight reaction to a potential stressor, which is associated with an activation of the human sympathetic nervous system. For instance, heart rate could increase when one experiences a sudden very loud noise. Chronic stress is stress that is emerging over a longer time.	Stress as a response / stress as an external stimulus
Fight-or-flight	Cannon	1932	Psychological response to an emergency situation resulting in fight or a flight response.	Stress as a response
General Adaption Syndrome (GAS)	Selye	1956	Three-phase model psychological response on stress (alarm, resistance and adaption)	Stress as a response
Stress Curve	Lazarus	1960	4 stages (too little, optimum, too much, and distress) of how people react to stress, distinguishing bad and good stress	Stress as a response
Transactional model of Environmental stress	Lazarus	1966	Reaction to environmental stressors including primary and secondary appraisal and coping	Stress as a process
The environmental load theory	Millgram	1970	States that overload (i.e. deriving from urban stressors) denotes people's inability to process inputs from the environment because there are too many inputs to cope with.	Stress as a response
The behavior constraint model	Prohansky	1970	Coping strategy suggesting that when people experience a loss of control in the face of environmental threats (stressors), they initially try to regain control.	Stress as a process
Adaption level theory	Wohlwill	1974	Individuals adapt to their environment and circumstances, leading to changes in their perceptions, evaluations, and behaviors over time. This is muchly related to habituation.	Stress as a process
Conditional model of stress	Moser	1994	Suggests that stress arises from an interaction between a person and their environment, but the effects of stressors depend on the individual's control, and perception of the control (understanding the threat and the ableness to choose).	Stress as a process
Allostatic load theory	McEwen	1998	Suggests that every time a person is confronted with a stressor, physiological systems are activated to find a new equilibrium that allows the individual to function in the changed situation.	Stress as a process
Flow theory	Csikszentmihalyi	2008	This theory states that if one wants to reach 'flow', meaning a feeling of satisfaction and focus arises when high challenges and high capabilities are met. In this manner, a challenging environment could help people reach feelings of 'flow'.	Stress as a response

From the year 1900, most theories on stress were focused on stress as a response, mainly from a psychological perspective. Cannon (1932) studied human and animal reactions to dangerous situations and concluded that they displayed adaptive 'fight-or-flight' responses when they were confronted with emergencies. Once the emergency had passed, physiological responses such as adrenaline release, blood pressure, blood coagulation, heart rate, and sugar levels in the blood turned

back to normal levels (figure 4 shows a visual representation of the physiological response to a stressor). This process of emergency and stabilization is called *homeostasis*. On the other hand, Selye (1956) looked into the adaptation of the human body to chronic challenges and proposed a three-phase pattern of stress response which he called the general *adaptation syndrome (GAS)*. The more recent *allostatic load theory* (McEwen, 1998), proposed a dynamic view of stress as a continuous effort of the body to achieve allostasis, or stability through change. This means that every time a person is confronted with a stressor, physiological stress systems are activated to find a new equilibrium that allows the individual to function in the changed situation.

Figure 4: Fight or flight is a physiological response to a stressor.



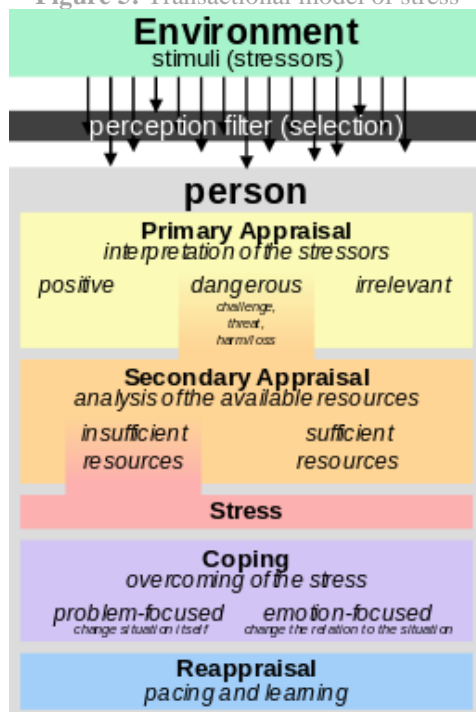
Source: <https://courses.lumenlearning.com/waymaker-psychology/chapter/studying-stress/>

The dominant conceptual framework in stress theory has shifted from stability (*homeostasis*) to adaptive change (*allostatics*) (Ganzel et al., 2010). Furthermore, the theories evolved more towards stress as a response, taking the environment into account. More recent stress theories are therefore more complete, by taking more aspects into account.

2.2.2 Transactional model of stress

One of the relatively more recent theories that take into account both stress as well as the environment is the *transactional model of stress* by Lazarus (1966). Within this theory, it is not only the individual that produces stress but instead more of a complex transaction between the environment and the individual (Folkman, 1984). Over the past five decades, this theory has been particularly instrumental, still relevant, and in development in shaping stress and coping research over the past decades. Figure 5 shows the *transactional model of stress* and is a significant part of the theoretical framework of this study.

Figure 5: Transactional model of stress



Source: Lazarus, 1966

The *transactional model of stress* is about stress and coping, and according to the model, individuals are constantly appraising stimuli within their environment. A continuous cycle of transactions between the individual and environment, experienced as disruptions to equilibrium and adaptive processes enacted to resolve this disequilibrium. When stimuli are appraised as threatening, challenging, or harmful, an individual initiates coping strategies to manage emotions or directly address the stressor itself. A coping process creates an outcome, which is reappraised as favorable, unfavorable, or unresolved. Wanted resolution of stressors elicit positive emotions while unresolved or unfavorable resolution elicit distress, provoking the individual to consider further coping option to resolve the stressor.

2.2.2.1 Perception

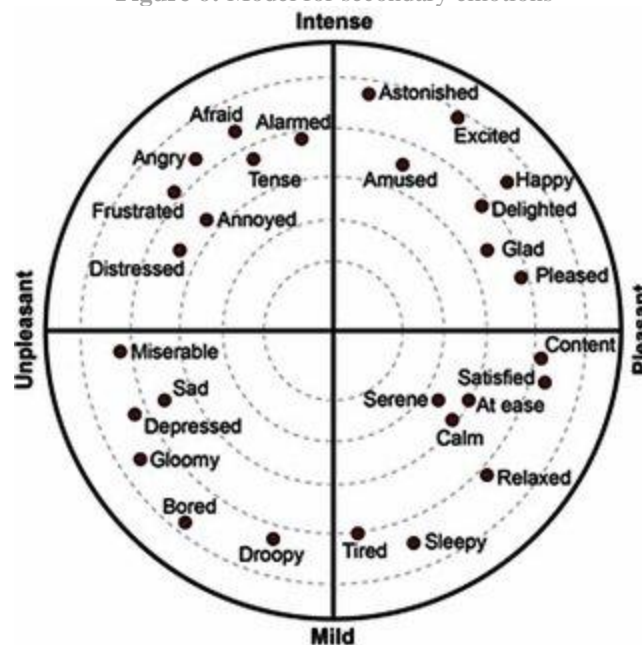
Perception works as a selection mechanism to start the appraisal process (a stressor is being perceived by an individual). Before going deeper into the appraisal process, it is important to expand the theoretical frame of perception. Perception is the main form of cognitive appraisal through which humans interact with the world (Efron, 1969). The meaning of one's environment can be different for each individual because the role of emotion for the individual and the appraisal of space and position in time and space plays a role (Davidson & Milligan, 2004). Therefore, perception is not objective, it is heavily influenced by cultural and social upbringing. Information we gather in the world around us is integrated with our prior knowledge, expectations, and beliefs to form a coherent representation of our environment (Goldstein, 2019). Nothing is inherently scary, we learn or rather we are enculturated, to be afraid of certain things. Perception can be influenced by various factors, such as attention, motivation, expectation, and context (Palmer, 1999). For example, when we are motivated to find something specific in our environment, we may be more likely to attend to and notice information related to that object. Perception related to stress is important to address because perception can influence the experience of stress. The way a situation is perceived or interpreted can impact the way stress is experienced (Lazarus & Folkman, 1984). Furthermore, the perceived control can effect the amount of stress (Glass & Singer, 1972). The more an areas is perceived as safe, the higher the sense of control is, reducing stress effects.

2.2.2.2 Primary and secondary appraisal

The main concept in the transactional theory is about appraisal, and can be distinguished into two

core forms or appraisals of similar importance and have a simultaneous interchange: namely: primary appraisal and secondary appraisal. According to Lazarus (1991), the appraisal is driven by two sets of forces, first, an individual's agenda, including their values, goals and beliefs, and environmental factors, such as demands and resources. This can be highly varied, due to the complex nature of the external environment on the one hand and the preferences of an individual on the other hand. The primary transaction can be distinguished as positive (positive effect on an individual's well-being), dangerous/stressful (when an event can induce harm/loss, threat, or challenge to an individual's well-being), or irrelevant (no significance to an individual's well-being). Mainly the second category is of main interest in this study because it can induce stress. While the primary appraisal is more in line with the 'fight-or-flight' reaction of Cannon (1932), the secondary appraisal is about a cognitive process where an individual goes through, an evaluation of their coping resources, situational variables (for example the authority constraint, referring to time-space geography and coping styles or the manner which the individual has coped with similar events in the past). The interaction between an individual and their environment is called an embodied experience, a sensory experience (via vision, hearing, touch, taste, and smell) (Holloway & Hubbard, 2001). According to the *transactional model*, when an individual has insufficient resources, stress occurs. Negative emotional states, such as fear, anxiety, sadness, guilt, annoyance, irritation, frustration or being overwhelmed can be considered stress and can be induced by a variety of stressors, such as environmental noise, traffic congestion, personal conflicts, or work-related demands (Verkuil et al., 2015; Lupien et al., 2009; Kessler et. al, 1997; Lazarus, 1999; Gross, 2002). The negative emotional states could also be considered as a form of subjective appraisal of a situation of a certain stressor (Lazarus, 1999). Adding on this, Figure 6 shows a model created by Russell (1980). The model explains secondary emotions (such as anger, calm, and boredom) determined by the level of arousal (mild to intense) on the vertical axis and the negative or positive valence (unpleasant to pleasant) on the horizontal axis. Valence in this context, represents the degree to which an emotion is experienced as positive or negative. Emotions with positive valence are those that are perceived as pleasant or enjoyable, while emotions with negative valence are those that are perceived as unpleasant or aversive. This dimension helps to categorize emotions along a spectrum ranging from very positive to very negative, with neutral emotions falling somewhere in between.

Figure 6: Model for secondary emotions



Source: Russel, 1980

2.2.2.3 Coping

Coping actions are enacted to shape, manage, or resolve the (stressful) event (Cooper, 2007). Within the transactional model, coping can be problem-focused (head-on action to resolve the underlying cause) or emotion-focused (regulating feelings and emotional responses instead of addressing the

problem). Broadly seen, emotion-focused coping is maladaptive, short-term resolving, and ineffective, while with problem-focused coping more positive effects have been shown. Problem-focused coping is generally associated with improved well-being, while emotion-focused coping is associated with more emotional exhaustion and lower health-related quality of life. Related to problem-focused coping strategies, Edwards (1992) conducted the cybernetic theory. This theory consists of five coping mechanisms that are defined as a reaction to minimize symptoms of strain, modify perceptions of desired actual mental states, and resolve discrepancies between perceived and desired mental states. Table 2 gives a brief description of the five coping mechanisms to expand the problem-focused coping as described in the transactional model of Lazarus (1966).

Table 2: Coping mechanisms and explanation

Coping mechanism	Explanation
Change the situation	Actively change the situation
Symptom reduction	Minimize the symptoms of ill-health
Avoidance	Repress undesirable aspects of a stressor
Accommodation	Adjusting own desires to get better aligned with the perceived situation
Devaluation	Mentally minimize the importance of the discrepancy

2.2.2.4 Further development of the transactional model

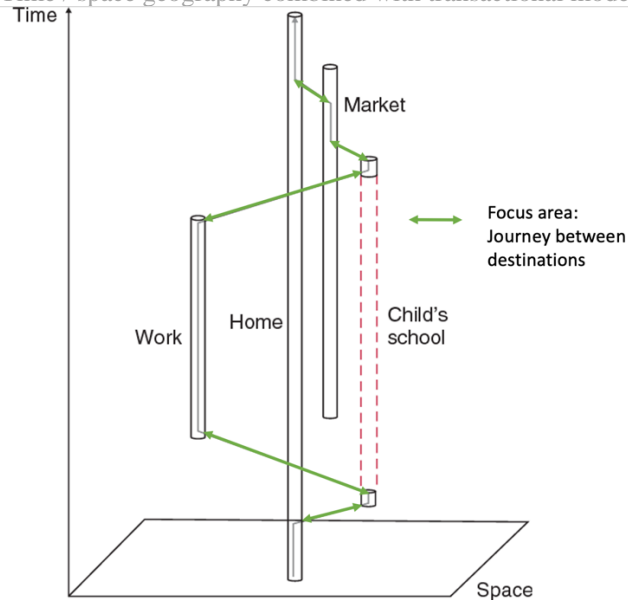
While the main pillars of the *transactional model of stress* are still relevant and used in contemporary research, some parts of the model have been in development throughout the decades. One of the parts is about *meaning-focused coping*. The original explanation of cognitive reappraisal determined whether coping efforts were successful or unsuccessful. Successful outcomes led to positive emotions and failure (or unsuccessful outcomes) led to distress which initiated further attempts to resolve the stressor. The revised theory proposed unsuccessful coping may trigger meaning-focused coping, particularly when stressors are perceived as aversive and overwhelming. This type of coping involves drawing on values, beliefs, and goals to reorder life priorities, ascribing positive meaning to ordinary events, and finding and reminding oneself of the benefits of stress (Carver and Connor-Smith 2010, Folkman, 2008). In this manner, *meaningful coping* can lead to positive emotions, which restore resources that influence cognitive appraisals, sustain coping efforts over time, and provide relief from distress (Folkman, 2008). This form of coping can also be seen as a form of changing perspective or relativizing. Lastly, some future directions of *the transactional model* are about *future-oriented coping* and the use of *ecological assessments* during research. To unfold *future-oriented coping*, table 3 shows 4 different types of future-oriented coping (Schwarzer, 2002). These types of coping can be applied to environmental stressors, for example, if a certain road is closed, people can pro-actively cope with this situation. People read information about road maintenance in a certain period and therefore have to adjust their journey and leave home earlier so they arrive at work at the expected time their employer asks of them (authority constraint). *Ecological assessments (EMA)*, are research methods that assess behavioral and cognitive processes within Participants' 24 natural environments and are helpful for future coping research, and will be described more extensively in the methods chapter.

Table 3: 4 types of (future-oriented) coping

Types of coping	Explanation	Example
Reactive coping (not necessarily future-oriented coping)	Undertaken to deal with harm or loss that already has been experienced	When someone walks into a crowded area and perceives this as stressful
Anticipatory coping	Enacted in response to a recognized upcoming event of likely certainty in the short-term future	Taking another route, seeing the preferred route is busy and stress-inducing
Preventive coping	Utilized to deal with potential future stressors, that are possible, while the eventual occurrence is uncertain.	Taking another route, expecting the preferred route could be busy and stress-inducing
Proactive coping	Focuses on the accumulation of resources to enhance one's potential and opportunities for personal growth. For example: actively attend workshops to enhance one's chances of a job promotion due to increased knowledge.	Taking another route, with certain aspects someone could learn or grow from. For example: a route with several cultural or educational purposes.

To integrate the *transactional model* of Lazarus (1966) into *time-space geography*, figure 7 shows the theory of Hägerstrand (1973), the green demarcated areas illustrates possible moments where the *transactional model of stress* will be applied during the walk-along research.

Figure 7: Time / space geography combined with transactional model of stress



Source: Own creation

2.3 Environmental stressors

When consulting literature on environmental stressors, there seems to be a need for a comprehensive view on stressors. Furthermore, a literature review indicates that researchers only dealt with several dimensions of public spaces that might affect stress (Sadeghpour et al., 2024). This section discusses different environmental stressors and factors that influence them based on the literature.

One of the most common stressors is crowding, and is about the tension someone has that arises from the number of people that are around them (Gifford, 2007; Evans & Cohen, 2004; Halpern, 1995; Loo, 1977). This differentiates from density, which is an objective measure to count the number of people in a certain area (i.e. people/km²) (Stokols, 1972). Crowding is about the subjective experience of a person and differs per individual. This subjective experience varies by a person's socio-cultural characteristics (personality, age, gender) and situational factors (i.e. private vs. public space or duration and type of activity). In a broader sense, there are two psychological processes why crowding harms people. The first one is a loss of control over the environment (Schmidt & Keating, 1979), an example could be a traffic jam where the surrounding traffic limits someone in the time the person will arrive at his or her destination. The other one is an overload of information and has a clear relation with the first psychological effect. If people are in a room with too many people, there could be an overload of information, this strengthens the feeling of lack of control, causing stress (Milgram, 1970). The other way around, if people try to control their environment, they lower the threshold of information overload (Baumeister et al., 1998). Crowding makes it difficult to regulate social interaction, limits behavioral options, and leads to invasions of personal space (Steg and De Groot, 2018). A lot of studies show that crowding leads to physiological stress (Epstein, 1982 & Gifford, 2007). Therefore, it influences blood pressure, heart functions, sweating, and other indicators of stress (Gifford, 2007). Crowding can be reduced if an urban design provides acceptable territory and privacy for an individual (Loo, 1977).

As already said, the experience of crowding differs per individual and situation; therefore, it is important to distinguish between physical crowds (physically together but there is no sense of being a group) and psychological crowds (sharing a feeling of 'groupness' for example a group of sight-seeing tourists or a group of soccer fans in a stadium). This relates to *'the shared social identity'*, this is a

process of depersonalization where individuals self-stereotype themselves as being in a group, shifting away from their social identity and identifying themselves as a member of the group (Templeton et al., 2018). In addition to this concept, the presence of others can also help to reduce fear and anxiety since humans are social creatures. Belonging to a group receiving social support, increases the chances of survival and achieving one's goals and therefore creates a "sense of security" (Brosschot et al., 2018; Ward Thompson et al., 2016).

Figure 8: Example of a crowd

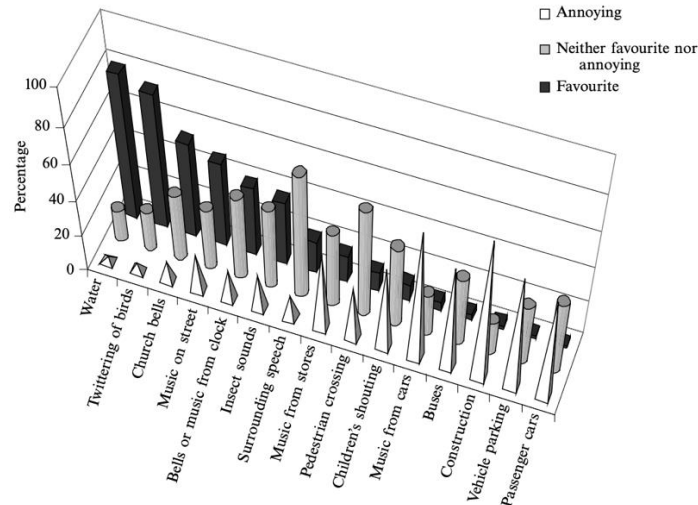


Source: <https://www.istockphoto.com/nl/fotos/crowded-street>

Another, more indirect stressor that can affect human mental health is climate change. Studies show that violence is more prevalent in warmer cities, and exposure to excessive heat increases the secretion of stress hormones (Halpern, 1995, Mazlomi et al., 2017, Cianconi et al., 2020). Factors that influence and reduce heat-island effects are green spaces and water-containing landscapes (Gruebner et al., 2018). Furthermore, cold and hot winds can produce stress and anxiety (Halpern, 1995). Wind could also produce sounds, that lead to stress (Brosschot et al., 2018).

Besides crowding, noise is mentioned in the literature as a dominant stressor that can arise in urban environments, and is defined as an unwanted sound (Glass and Singer, 1972). Different types of noise could arise from traffic, horn honking, construction sites, sirens, or loud music. Different sounds may be perceived differently by different people (individual sensitivity) or by the same person in different contexts (loud music at a concert or during bedtime). A study by Zhang and Kang (2005) showed people had a very positive attitude toward natural sounds and were more annoyed towards mechanical sounds (such as construction, music from cars, and vehicle parking) (see figure 9). Other studies show that natural sounds can calm the mind and reduce stress (Alvarsson et al., 2010; Linnemann et al., 2015; Thoma et al., 2013; Thoma et al., 2018).

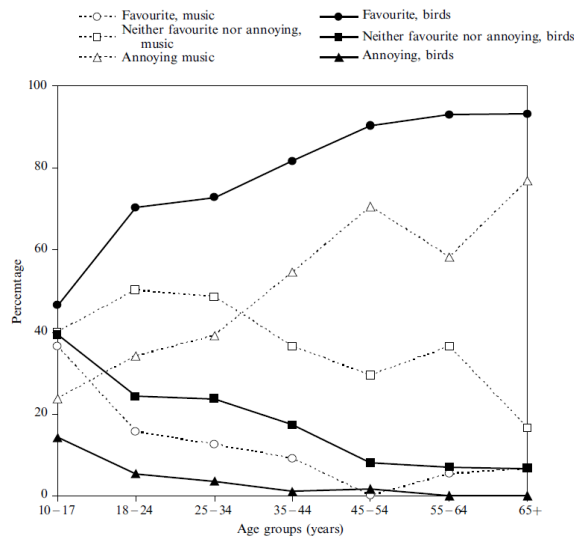
Figure 9: Classification of typical sounds in urban open spaces, based on the survey in Sheffield.



Source: Yang and Kang, 2005

Other variables within noise experience could be duration of exposure, settings or environmental quality. Besides hearing loss, noise can produce non-auditory effects, such as annoyance, communication or task interference, sleep disturbance, increased psychological distress, hypertension, or impaired development and memory, these effects all relate to stress-response outcomes (Kamp & Davies, 2023; Westman, 1981). Cohen and Spacapan (1984), showed that greater noise levels in urban areas could also lower the degree of helping behavior towards other people, meaning less altruism. Appleyard (1981), showed that high traffic noise is related to lower levels of safety perception. The different effects of stress, induced by noise could also be experienced differently by sensitive individuals, they could pay more attention to sound and evaluate it negatively and also have stronger emotional reaction reactions to noise and therefore bring more difficulties in habituating to noise (Stansfeld, 2003). This is also shown in a study by Zhang and Khang (2007), where different groups of age were exposed to different sounds, and different heights of appraisal were given to the different sounds (see Figure 10).

Figure 10: Variation of sound preference amongst age groups for birdsong and music from stores



Source: Zhang and Khang, 2007

The interaction of multiple sensory stimuli, for example, sound and visual can enhance the effect of sound, or noise (Westman, 1981). Also, the predictability of the sound is an important determinant of response, unpredictable noise resulted in a lower tolerance for frustration and greater impairment of

performance efficiency than predictable noise (Glass et al., 1969). This could be different for different types of persons since high-risk seekers might be more likely to be more tolerant of unpredictability (Gottholmseder et al., 2009).

Besides the psychological effects of noise, the urban environment, namely an urban canyon can have a significant effect on the noise experience (Echevarria Sanchez, 2016). This is because the sound waves induced by for example traffic, are amplified by buildings on two sides of the streets (as shown in Figure 11). Tall buildings, for example in an urban canyon can also intensify winds and reduce comfort (Halpern, 1995).

Figure 11: Example of an Urban Canyon



Source: <https://medium.com/the-machinery-of-government/canyon-effect-in-australian-cities-ce496190c760>

An abundance of studies has proven air pollution (mostly related to traffic) affects health. Air pollution can affect oxidative stress, neuro-inflammation, cerebrovascular damage, and neurodegenerative pathology. Most of these studies focused, on and proved the negative effect on physical health, while the amount of studies on air pollution affecting mental health is limited (Hanna et al., 2019). Mental health relates to a state of well-being in which an individual can cope with stress, work productively, and contribute to the community (World Health Organization, 2014). Although the amount of studies on air pollution and mental health is limited, Tzivian (2015), showed that a relation between air pollution and mental health exists. A longitudinal study by Chen et al. (2018), using a panel study under 12.615 residents during a year showed that (18.04 $\mu\text{g}/\text{m}^3$) increase in average $\text{PM}_{2.5}$ concentrations in the past month increases the probability of having a score that is associated with severe mental illness by 6.67 percentage points, or 0.33 standard deviations. Another study, of Bakolis et al. (2020), surveyed 1698 adults living in 1075 households in South East London and suggested that traffic-related air pollution was adversely affecting mental health. Other studies suggest that negative personality traits are more prevalent among residents in areas with polluted air (Sadeghpour et al., 2024).

Furthermore, air pollution can cause people to spend less time outdoors, reduce physical activity, and contact with nature, and limit exposure to sunlight and vitamin D efficiency (Pelgrims et al, 2021). Physical diseases induced by air pollution, such as lung or heart diseases can further exacerbate anxiety, fear, and stress negatively affecting the mental health of a person (Ghorani-Azam et al., 2016). Air pollution can also affect mental health in other indirect ways, Fu et. al (2018), and Chang et al., (2016), showed that air pollution can significantly reduce labor productivity. The lack of productivity can reduce the income of workers and increase stress and fear of unemployment, which both endanger mental health (Gardner and Oswald, 2007). Unpleasant odors, such as air pollution are an important factor in creating fear, anxiety, and stress (Schweitzer et al., 2004), whereas the smell of the fragrance of rose or lavender has a positive influence of olfactory sense on the reduction of stress (Kianpour et al., 2016).

Tzvian et al. (2015), also mention that visibility of particulate matters (such as exhaust gasses) can generate stress responses. Yilmaz & Sagsoz (2011), indicate that visual pollution on mental health has become a more important research subject. Visual pollution may lead to behavioral disorders and stress. Furthermore, visual comfort is affected by components such as color, brightness, green space, order or cleanness (Allahyari et al., 2017). Colors affect the secretion of hormones and contribute to different emotions, behavior or personality traits (Dargahi & Rajabnezhad, 2014). According to Kutchma (2014), people experience more stress in a red room than in a green or white room. Color, used in art can also affect the experience of stress, for example if abstract paintings depict chaos or disorder (Hassell, 2014), whereas images of positive subjects, nature, friendly relationships between people having a positive association with stress (Schweitzer et al., 2004). Also the material used in design of products in the urban environment can influence human feelings (Crippa et al., 2019). Light and brightness affect stress, whereas artificial light can create a lousy mood and restlessness and natural light increases that recognition of visual details and a better perception of information (Schweitzer et al., 2004). Having more light relates to having a better understanding of information and that relates to having a "sense of security" in the urban space. If an individual feels secure in an environment, the stress mechanisms are deactivated (Brosschot et al., 2018). Other factors that cause stress are the feeling of being victimized and neighborhoods with high crime rates are likely to have higher stress levels (Cultrona et al., 2006). Table 4 summarizes the most important environmental stressors according to the literature.

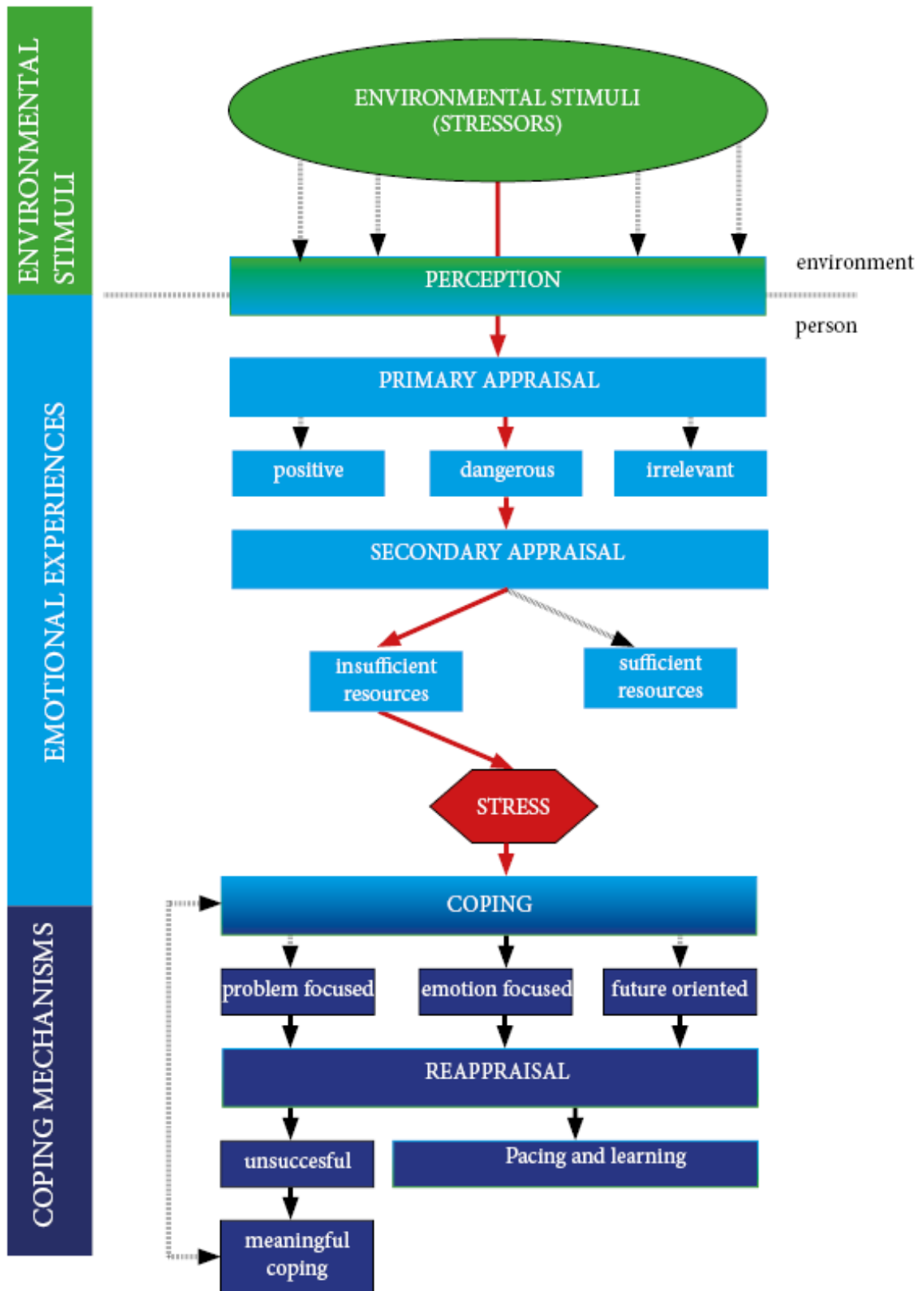
Table 4: Overview of environmental stressors according to the literature

Environmental stressor	Study	Explanation
Crowding	Gifford, R. (2007); Evans, G. W., & Cohen, S. (2004); Loo, R. (1977).	The feeling of tension arising from the presence of too many people in a given space. It affects individuals subjectively and can lead to a loss of control over the environment and an overload of information, both contributing to stress.
Climate change	Halpern, D. (1995); Mazlomi, A., et al. (2017); Cianconi, P., et al. (2020); Gruebner, O., et al. (2018)	Indirectly affects mental health through factors like increased violence in warmer cities, exposure to excessive heat, and the amplification of stressors like wind.
Noise	Glass, D. C., & Singer, J. E. (1972); Zhang, M., & Kang, J. (2005); Kamp, I., & Davies, H. (2023)	Unwanted sounds in urban environments, such as traffic, construction, or loud music, can lead to annoyance, sleep disturbance, and increased psychological distress, contributing to stress.
Air pollution	Tzvian, L., et al. (2015); Bakolis, I., et al. (2020); Hanna, R., et al. (2019)	Particularly related to traffic, air pollution affects physical health and can also have adverse effects on mental health, including increasing the probability of severe mental illness, reducing outdoor time and physical activity, and inducing fear and anxiety.
Visual pollution	Allahyari, M. S., et al. (2017); Dargahi, S., & Rajabnezhad, M. (2014); Hassell, S. (2014)	Visual elements such as cluttered or disorderly environments, unpleasant odors, and unfavorable colors or lighting can contribute to stress and negatively impact mental health.
Safety perception and crime rate	Cultrona, T. A., et al. (2006)	Feelings of being victimized and living in neighborhoods with high crime rates can significantly increase stress levels.

2.4 Conceptual model

During a trip through time and space, individuals can experience stress. Stress is the result of an imbalance between environmental conditions and individual response capabilities. When challenges exceed individual capabilities, stress occurs. Perception plays a crucial role in the experience of stress. According to different stress models, stress can be helpful at a low dose but damages mental health when it exceeds different limits, which differs for every individual. Stress theories moved from a focus on homeostasis to allostasis, an adaptation stage, where a body tries to achieve stability through change. The main categories of environmental stressors that were found in the literature were crowding, climate change, noise, air pollution, visual pollution and safety perception and crime rate. Figure 12 shows the conceptual model of this research and uses the core elements of Lazarus's transactional model (1966) and enriches it with more recent components. The model shows the process of how an individual experiences environmental stimuli, the emotional experience that emerges, and the way how an individual copes with a stressor. During the walk-along research, this conceptual model provides a frame in which different observations during the walk-along can be defined. Other theories and concepts on stress, as described in this research are also taken into account, to provide meaning to the different observations.

Figure 12: Conceptual model



Source: Own creation of the enriched transactional model of stress

3. Methods

As described in the introduction and the theoretical framework, there is an scientific urgency to focus more on 'momentary perception' regarding urban stressors and embodied experiences. Every individual has their perception, which emerges from their knowledge, expectations, and beliefs (Goldstein, 2019). This chapter aims to ensure the suitability, reliability and validity of the research methods. The chapter starts with describing the research area followed by a description of the decisions of why certain qualitative research methods are used, the process how and why Participants have been chosen including the operationalization of these methods, namely walk-along research in combination with video recordings.

The research area that was used for this study is mainly located in the city center of The Hague, the Netherlands. This area is very highly urban and has around 11.000 inhabitants per square kilometer (CBS, 2023) compared to 6827 inhabitants per square kilometer for the whole city. The most walks were within a more specific area: neighborhood and is called: the Central Innovation District (CID) (see Figure 12). This area is located within three railway stations and is known to be the vibrant and economic heart of The Hague and the city region. The area offers work to almost 80.000 people, provides education for approximately 30.000 students, and inhabits around 45.000 residents in around 23.000 houses (Municipality of the Hague, 2023). The area is an important transport hub, used by more than 200.000 people every day on their daily trips way to work, home, or recreational facilities (The Hague, 2021). The walking routes in the CID area are well-used, with several interferences like car roads, bicycle lanes, and tram connections. Furthermore, the area has shops (with objects such as tables on the streets), offices, and an university that attracts a lot of (commuting) people throughout the day. Lastly, large parts of the area are designed as a shared space area. A shared space design, also known as a shared street or a shared surface, is an urban design concept that aims to create a more inclusive and harmonious environment for pedestrians, cyclists, and motorists by blurring traditional distinctions between different modes of transportation. A shared space design is meant to give priority to pedestrians and cyclists, while vehicles are encouraged to move at slower speeds and interact more cautiously with other users of the space (Barr et al., 2021).

Figure 13: Central Innovation District (CID) The Hague



Source: <https://projecten.denhaag.nl/gebied/central-innovation-district/>

3.1 Walk-along research

Different research methods have been assessed before choosing the walk-along method. There are different ways of measuring stress, for example by using self-report questionnaires such as Holmes and Rahe Stress Scale, Cohen Stress Scale (Hellhammer et al., 2010) and the Depression Anxiety Stress Scales (DASS) questionnaire (Lovibond & Lovibond, 1995). Reviewing these type of questionnaires show these methods do give insight into stress, but mainly stress that comes from different aspects of a person's life, rather than stress induced by the environment on-site. Biotechnical ways of measuring stress such as measuring cortisol levels (Roe et al., 2013), measuring skin conductivity (Layeb et al., 2016) or EEG tests (Aspinall et al., 2015) could be suitable for this research but lack of funding did not made this kind of research methods not possible. As described in the theoretical framework; Ecological assessments (EMA), are research methods that assess behavioral

and cognitive processes within Participants' natural environments and are helpful for future coping research. The most important components proposed by Stone and Shiffman (1994), that define EMA's are (1) assessments are made as they occur, (2) assessments are carefully timed, (3) repeated observations are often made and (4) the assessments are in the Participants' environment. This contrasts with diary studies, which are often made once per day. Although these methods have been used over the last 25 years, recent advancements in technology have enabled researchers to assess thoughts and behaviors with relatively less difficulty for Participants. The EMA research method aligns with the method that is used for this research, namely, the walk-along research that will be done 3 times a day (morning peak, break walk, and evening peak) per Participant, and on different days. This also aligns with the required research/research gap on environmental stress, namely the necessity to capture momentary experiences. To gain an in-depth understanding of 'real-world' Participants' experiences, walk-along research has been chosen. The goal of the walk-along research is that the researcher gets immersed in the Participants' world and their 'journey', the walk-along research method therefore fits in the goal of this research (Bibi & Ehgartner, 2021). Walk-along research can give rich and detailed insights into the participant's experiences, perception, and emotions and their interaction with the physical and social environment (Pink, 2015). During a walk-along research, Participants can address nuances and complexities in real-time contributing to a deeper understanding of the sources of stress. In addition, during a walk-along research, subjective expressed perspectives and narratives can be captured, as well as coping strategies. In the process, the researcher-participant interaction of asking questions fades into the background, in favor of a conversational encounter between two people (Bibi, Ehgartner, 2021). In this study, a 'natural go-along' approach was chosen over a 'guided walk' method (Evans & Jones, 2011). In that sense, the participant took the lead, addressing the topics he or she wanted to address which are meaningful to them or they wanted to walk by or are most familiar with. To add a visual dimension and to capture surroundings and experiences during the walk-along, research Participants were provided with a camera. The visual material provided clarity and a more authentic representation of their experiences. The research was recorded by using a GoPro11 Black, with a connecting element around the Participants' waist. The Apple Watch version 9 was used to track the routes, times, walking speeds, and weather conditions (such as temperature in degrees Celsius, humidity, and cloudiness) and the amount of kilometers of the walk-along. An iPhone 11 pro was used to record the walk-alongs for transcription on a later moment.

Despite the suitability of this method for this research, there are some limitations. One of the limitations is the observer bias, this could lead Participants to alter their behavior knowing they are observed (Hróbjartsson et. al, 2012). The way that was dealt with this was to do the walk-alongs in a natural way since there was chosen for a natural go-along instead of a guided walk. An other aspect that could be a limitation are the ethical concerns. To ensure privacy and anonymity the Participants were asked for informed consent (see Appendix 2 for the Informed Consent form). They were informed how the data extracted from the research was stored, protected, and analyzed. With the informed consent, the participant's preferences and comfort levels were taken into account, regarding what they chose to document and share. Furthermore, positionality during this research could have effect on this research. The recognition and acknowledgment that researchers are not detached or natural observers but rather individuals with their own social, cultural, and personal background shaping their perspective and research outcomes refers to positionality (Hay, 2021). My position in the research is as follows, I am a married male of 33 years old living in a small city in the Netherlands. My background is in urban planning, and my working career is in innovative solutions and behavioral change within mobility. I worked as a consultant within the field of mobility, and now working as a policy advisor on mobility at the municipality of The Hague. The participants, who are colleagues working at the municipality, may find it easier to share information comfortably due to their shared professional context. However, they may also feel less inclined to disclose personal experiences with stress, perhaps due to concerns about maintaining boundaries between their work and personal lives. The last part that could be challenging is the fact that during the recording other kind of noises such as wind, or people talking, public transit, cars and so on can have an effect on the voice recording (Clark & Emmel, 2010), extensive transcribing was a solution for this.

3.2 Participants

Between 5 July and 5 October 2023, in total 16 hours and 53 minutes of walk-alongs were conducted. This resulted in a total of 79,14 kilometers with 42 walk-alongs (morning, afternoon, and evening) with 14 Participants in total. The research took place in three different ways, firstly the commuting trip during the morning rush hours (between 06.30 a.m. and 9.30 a.m.) to the office location. The second trip was an 'off-peak moment', for example during the participant's lunch break (between 12 and 13.30 in the afternoon). The third walk-along research moment was during the Participants' commuting trip back home (also during rush hours between 3.30 p.m. and 7 p.m.). Important to mention is that in 10 cases, the walk-long was from one's home address and back, and in 4 cases it was 'the last mile' from a transport stop to the work address and back to the transport stop (with a minimum of 1 kilometer walking). Different moments during the day were chosen to capture possible differences during different times of the day. The rush hour times are based on data from the ANWB (the Royal Dutch Touring Club). The number of kilometers walked, between male and female Participants was almost equally divided. The 14 Participants were aged 28 – 57 years (mean = 40,4) and highly educated. It is important to note, that this research was mainly conducted during 'summer vacation time'. In some cases, Participants described it could normally be busier than during the vacation times at certain locations, and talked about those experiences. On the other hand, certain locations were described as 'this is busier than normally' referring to the vacation time just having a mild effect on the research outcomes. Regarding the summer season, the weather was generally pleasant weather to walk in. This varied from 14 to 28 degrees Celsius, with a mean temperature of 19 degrees Celsius. In only 2 of the 42 walk-alongs, there was rain during the research. In some cases, Participants showed some insecurity about whether their contribution was sufficiently interesting for the research. During the walk-alongs, in general, the Participants had a positive and open attitude, they liked to observe new things, things they were not aware of. The walk-along also made some Participants more aware of certain aspects of their route that contributed to stress-related feelings helping them to choose more stress-free routes in the future. In general, the Participants were all highly educated, mostly all native-born Dutch, and the lion's share of them had a role in the mobility department. Every participant was approached by the researcher via e-mail, phone, or face-to-face if they were interested in joining the research. Sometimes via 'snowballing', asking Participants who joined the research if they might know other colleagues who lived near the workplace (Naderifar, Goli & Ghaljaie, 2017).

The Participants were free to choose if they wanted all three walks on the same day or to do them on different days. Eventually, 12 of the Participants did the 3 'walk-along moments' on the same day, with 2 other Participants, the morning, afternoon, and evening walks were planned on different dates. One day before each 'walk-along' the participant was called by the researcher to make sure what the goal of the research was and to discuss some practicalities such as where to pick someone up at an agreed time. At the beginning of each walk-along, the researcher briefed the participants on the research objectives. They were informed that they had the freedom to select their own route and to openly discuss their preferences, dislikes, and coping strategies based on the theoretical framework. Appendix 1 shows the full guidelines of the walk-alongs. From all participants, there was a clear confirmation to the question if they knew the route, so all Participants had a certain familiarity with the route. When Participants in walk-along research are familiar with the area being studied, they are more likely to provide genuine responses rather than trying to cater to the expectations of the researcher. This familiarity helps to foster an environment where Participants feel comfortable expressing their true opinions and perceptions, contributing to the authenticity of the data collected (Evans & Jones, 2011). During the research, two Participants mentioned they were 'highly sensitive', and one Participant mentioned she has traits of 'HSP' referring to highly sensitive people. According to Aron (1996), people with HSP are more sensitive and therefore are more affected by stressors. Persons with HSP tend to get overstimulated faster by external stimuli, such as noise, light or emotions, and therefore tend to get overwhelmed faster in specific environments such as a highly-dense urban environment. According to Aron, around 15-20% of the world's population can be classified as Highly Sensitive Persons (HSPs). While HSP is not recognized as a medical or psychiatric diagnosis by the DSM (Diagnostic and Statistical Manual of Mental Disorders) or ICD (International Classification of Diseases). Though it is not a formal diagnosis, many people identify with the aforementioned characteristics associated with high sensitivity and find value in understanding themselves through this framework. In the context of this research, it is plausible that High Sensitive Persons (HSP) are more susceptible to experiencing negative impacts from stressors encountered in

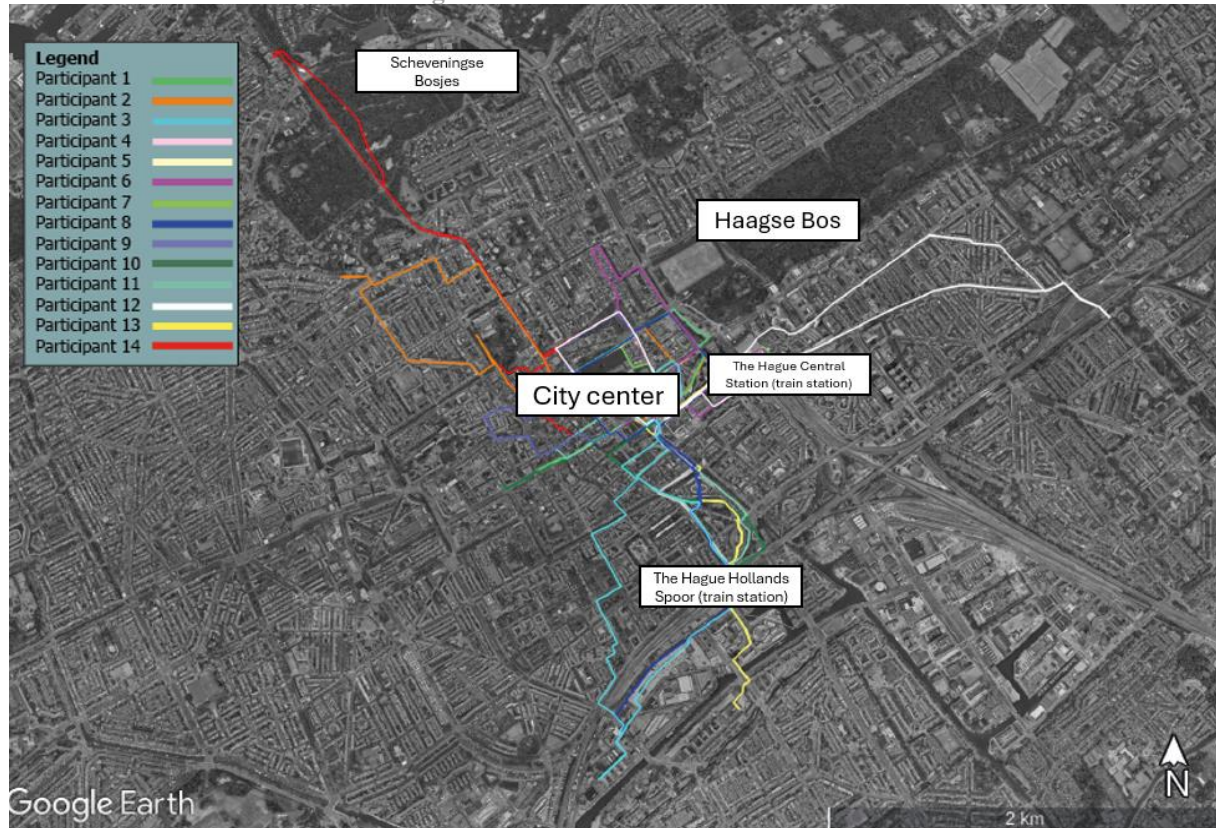
urban environments during their walking commute to work. Table 5 shows the different Participants, their gender, age, familiarity with the route, if they were highly sensitive or not, the department they worked, their education level and if the route was from home, or from a transport stop and back.

Table 5: Information about the Participants

Participant	Gender	Age	Familiar with route	Highly sensitive	Department	Education level	From home address or from public transport stop	Duration walk-long (in minutes, rounded up)			
								Morning	Afternoon	Evening	Total
1	Male	40	Yes	Not confirmed	Mobility	Bachelor	Public transport stop	12	26	11	49
2	Male	53	Yes	Yes	Sustainability	Master	Home address	28	28	32	88
3	Male	31	Yes	No	Emancipation	Master	Home address	42	17	37	96
4	Male	31	Yes	Not confirmed	Smart City	Master	Public transport stop	14	16	14	44
5	Female	31	Yes	Not confirmed	Sustainability	Master	Public transport stop	8	13	7	28
6	Female	43	Yes	Not confirmed	Mobility	Master	Home address	21	35	16	72
7	Female	43	Yes	Not confirmed	Mobility	Master	Home address	13	19	12	44
8	Male	28	Yes	Not confirmed	Mobility	Bachelor	Home address	26	32	29	87
9	Female	52	Yes	Not confirmed	Mobility	Master	Home address	15	28	18	87
10	Male	48	Yes	No	Mobility	PhD	Home address	15	28	18	61
11	Female	32	Yes	No	Mobility	Master	Public transport stop	15	22	15	52
12	Male	57	Yes	Not confirmed	Mobility	Master	Home address	38	31	41	110
13	Female	34	Yes	Yes	Communication	Bachelor	Home address	29	32	32	93
14	Female	45	Yes	Yes	Mobility	Master	Home address	44	37	41	122

Figure 13 shows the variety of routes the Participants have walked in the city center. Each color represents a Participant with the three moments during the day.

Figure 14: Overview of walked routes



Source: Own creation (with Google Earth as basis).

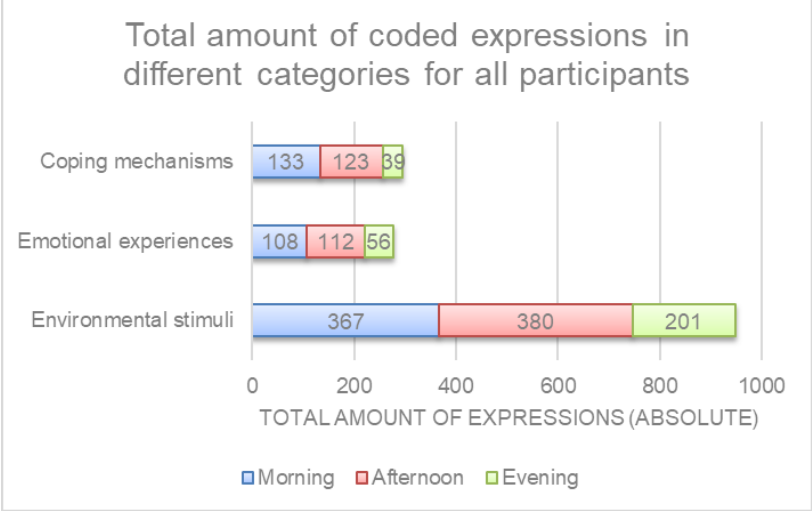
3.3 Operationalization

This research has a blend of deductive reasoning by starting from a conceptual framework and test it's hypotheses but also it also incorporated elements of inductive reasoning through the exploration of new concepts and insights emerging from the data. To start, a form of content analysis was done, which has been generally defined as a systematic technique for compressing many words of text into fewer content categories based on explicit rules of coding (Berelson, 1952; Krippendorff, 1980; Weber, 1990). The next section describes the individual steps that have been taken to operationalize the data. Firstly, the 42 audio recordings were uploaded to the transcription tool of Microsoft Word. Since the tool does not accurately transcribes (sometimes due to noise), the researcher needed to process all the individual transcriptions into text which resulted in a thorough understanding of the obtained data. Afterwards, the transcripts were imported into NVIVO version 14.0 to make use of Computer Assisted Qualitative Data Software Analysis (CAQDSA). Since the walk-alongs were done in three different time periods (morning peak hour, afternoon and evening peak hour), three codes for this time periods were made. Within those codes, three main codes were chosen, based on the conceptual model, namely environmental stimuli, emotional experiences and coping mechanisms adding a slightly deductive dimension to the coding process. Different expressions of participants were added to the main categories. The next step was to identify subcodes within the main codes by 'thematic coding', which is especially useful for gaining insights in people's experiences (Caulfeld, 2019). Some of the concepts identified aligned with the concepts or theories written in the theoretical framework, and others were newly found, the first coding tree can be found in Appendix 3. Since the data was so rich, a new main code about 'positive expressions' was made. Within those codes the same cycle of thematic coding was applied. This coding tree can be found in Appendix 4.

The next step of the analysis was transferring the NVIVO data to Microsoft Excel to combine data and make descriptive graphs of Participants' expressions towards different codes. In this sense, some aspects were more striking than others since they were mentioned more often. It is important to note that the graphs that will be shown depict the total amount of expressions. It could be, that one Participant expressed more than other Participants, for example, simply because this person was a

more extravert person or that the walk-along interview took longer. It could also be that there is a slight overlap in expressions. This is because every expression is coded, when someone mentions cars, it is coded, when someone mentions 'motorized traffic' it was also coded. Figure 14 shows the total amount of expressions towards environmental stimuli, emotional experiences, and coping mechanisms coded, divided by the different times of the day.

Figure 15: Total amount of coded expressions in different categories for all Participants



Source: Own creation.

What stands out is that the expressions that were coded, were mainly in the 'environmental stimuli' category followed by coping mechanisms and emotional experiences. It seems that the Participants had more ease with mentioning stimuli and less ease with mentioning their feelings and specific coping mechanisms. Sharing their emotional experiences towards specific stimuli could be exciting, or they might felt too vulnerable to do this. What also stands out is that most expressions were shown during the morning peak and the afternoon walk. The morning walk, and the evening walk, in most cases took the same amount of time (the route was mostly the same). One possible reason of this imbalance is fatigue. The video recordings where used to add *on-site* pictures momentary experiences to the results chapter, supporting the findings.

4. Results

This chapter consists the results of the research, describing the encountered environmental stressors, coping mechanisms and elements that contribute to less stress in the urban environment.

4.1 Environmental stressors

This section describes the encountered environmental stressors. These are shared space areas that are perceived as an unclear design and "the fight over space", crowding, conflicting ways of walking, obstacles and lack of space for pedestrians.

4.1.1 Unclear design, shared space and "the fight over space"

Large parts of the central area of The Hague are designed as a 'shared space' area and was by many Participants perceived as an 'unclear design' resulting in feelings of unsafety and sometimes stress. Areas where various traffic flows mix within public spaces are often referred to as 'shared-space' zones. Over the last two decades, policymakers worldwide have integrated elements of shared space design to foster pedestrian-friendly environments (Beitel et. al, 2018). Hamilton-Ballie (2008), characterizes shared space as a setting where all road users interact based on informal social protocols and negotiations. The primary objective of a shared space is to enhance pedestrian movement and comfort by diminishing the dominance of motor vehicles, allowing all users to share the space rather than adhere to rigid, conventional rules (Transport Document, 2011). The safety aspect of shared spaces remains debatable, with opponents, particularly elderly and disabled road users, expressing unease due to their perception of decreased safety (Winterberg & Bredmose, 2008). To address safety concerns, some Dutch cities are reverting shared spaces to their original designs as citizens perceive these areas as hazardous (Binnenlands Bestuur, 2020). There exists a theory suggesting that people adjust their behavior based on their perceived safety level, referred to as risk-compensation or risk-homeostasis (Wilde, 1998). Feeling safer may lead individuals to take more risks, such as driving faster, while a diminished sense of security prompts cautious behavior, like slower driving. Shared spaces leverage this concept by fostering an environment with fewer rules, encouraging people to adapt their speeds or heighten their alertness, potentially mitigating collision risks. Safety encompasses both objective measures, such as accident statistics, and subjective feelings of safety, absence of threat, and perceived risk (CROW, 2011). While society commonly acknowledges the safety benefits of features like traffic lights, the perception of safety in shared spaces may differ. Moody and Melia (2011), state that subjective safety can be less good for vulnerable groups such as children or the elderly. If pedestrians, especially the elderly or those with impairments, perceive heightened risks, they might avoid shared spaces, inadvertently leading to unintended segregation on the streets (Kaparias et al., 2012). Figure 15 shows one of the biggest shared space areas in the city center of The Hague, namely; De Grote Marktstraat.

Figure 16: De Grote Markstraat, The Hague during a regular afternoon



Source: <https://denhaag.com/en/travel-trade-the-hague/image-library>

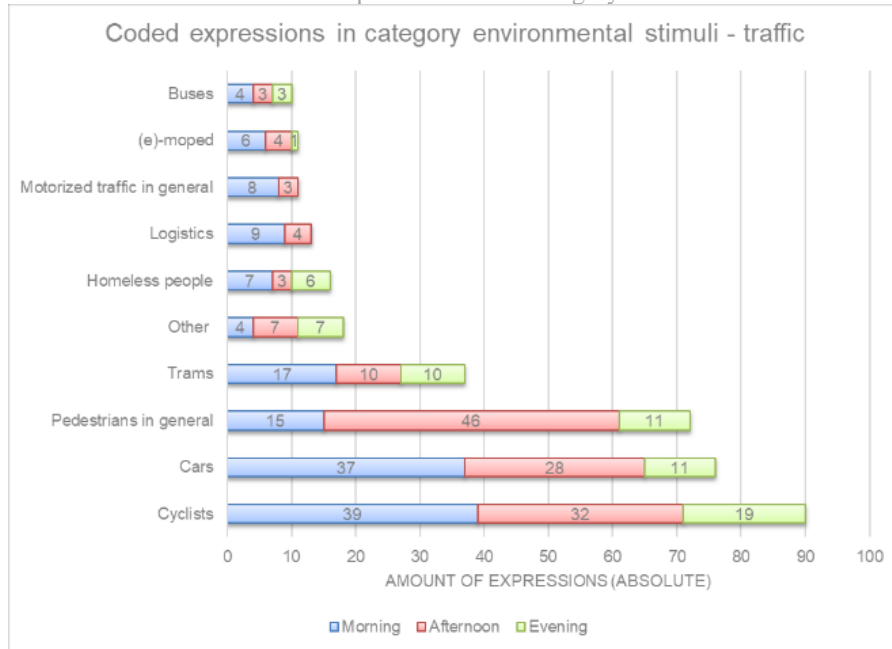
During the walk-alongs, a complex interplay between on one hand social factors, namely; rights that seems to be claimed by different users was clearly shown. On the other hand, urban design factors namely unclear design and less space for pedestrians stood out. This was resulting in tensions in space, resulting in negative emotions and therefore stress. This was especially the case in shared space areas during the afternoon and evening rush hour walk-alongs since the amount of traffic grew in comparison with the morning.

For example, this 40-year-old male Participant perceived a situation as dangerous, because he had the feeling he could have been driven by a cyclist. He felt frustrated, expressed anger, and even tended to provoke discussions with cyclists about whether it was their area to cycle or his area to walk.

"Because I'm going to walk here, that's what I often do. Yes, then you have to take a good look. You will be knocked over by a cyclist here. That's not relaxed. Sometimes I have the feeling that I have to walk there because it is not a cycle path, but then you are provoking it a bit and that is not relaxed either." (Participant 1)

The Participants expressed cyclists as the most common environmental stimuli in the category traffic. Cars and other pedestrians were mentioned as second and third (see figure 16). In the shared space area where conflicts with cyclists were most prevalent, cyclists were frequently traversing along a continuous route. According to the CROW (2023), continuous routes should not be used in a shared space since people feel less ownership of space in continuous routes compared to their destination or residential areas. This could be, because people (in this case cyclists) feel less involved because they do not live or work near, or they have their destination somewhere else. This could have negative influence of the functioning of shared space.

Figure 16: Total amount of coded expressions in the category environmental stimuli – traffic



Source: Own creation.

The following quote explains more about the right road-users think they have on specific road-segments and are not planning to make room for other road-users:

"While as a pedestrian or as a cyclist I just have the right to be there, I'm really not going to make room for that car to go faster or whatever. That's the space you're entitled to!" (Participant 11).

It shows there is a sort of *"fight over space"* going on. Each road-user, pedestrian, cyclist, car user or public transport driver behave in a way they think they have the right to use public space which is causing tension in space. This kind of behavior highly relates to territoriality. Territoriality is defined as behavior by which an organism lays claim to an area, creates a tangible or intangible boundary, and defends it against members of its own species (Hall, 1969). Research of Brower (1980), showed that when stress and nervousness increased, territorial tendencies intensified. It seems that this process occurred between the Participants who felt ownership with the area and on the other hand, the cyclists that felt less ownership since they were on a continuous route on their way to their destination. To add on this; Participant 1 mentioned being forced by other road users in the following manner:

"Well, you feel a little cornered. And there are several places in the city where you, as a pedestrian, just don't have enough space, which is just not logical to walk." (Participant 1)

This conflict with other users relates to the fact that Participants perceive the area as unclear and do not know where to walk (safely) in the city center, and sometimes, there was no place to walk at all:

"This is actually kind of like that again; Is this a bike path, or, what is it?" Or is this the path for pedestrians?" (Participant 10)

Figures 17,18 and 19 show different examples of *on-site* situations that were perceived and described as 'unclear design' by the Participants.

Figure 17: Example 1 of perceived 'unclear design'



Source: Own creation

Figure 18: Example 2 of perceived 'unclear design'



Source: Own creation

Figure 19: Example 3 of perceived 'unclear design'



Source: Own creation

The effect of these situations often results in uncomfortable or stressful feelings because with so little space it can not easily be coped with. This is perceived clearly by this 31-year-old female Participant, it seems this Participant felt uncomfortable at the time she was experiencing this:

"Here you have literally... The sidewalk is moved by the terrace, so pedestrians already have to enter the cycle path. Look, you can't! This is the worst! Make sure there is a clear marking for the bike path! So that you can walk well on the cycle path. Especially if you are just an unsuspecting tourist, and you have no idea what's here, yes then it makes sense that you are going to walk here. But this is life-threatening, especially with all those e-bikes." (Participant 5)

Figure 20: The experience of Participant 5, perceived as an unclear design



Source: Own creation

The unclear design mentioned by the Participants relates to legibility. Legibility, related to urban design, is an important aspect that influences the sense of security and safety and decreasing stress and anxiety (Brosschot et al., 2018; Mccay et al., 2017, Tabatabaian & Tammannaee, 2014). Legibility relates to cohesion and integrity, allowing a better perception of environmental stimuli which could reduce tension (Knöll et al., 2017). In an environment with a space design that is legible, someone can perceive components in an integrated framework without any information contradiction and ambiguity in mind, causing more control over the environment and less stress (Tabatabaian & Tammannaee, 2014).

4.1.2 Crowding and conflicting ways of walking

Not only, there are conflicts with cyclists or motorized traffic, but there are also conflicts with other pedestrians, who sometimes walk in an other rhythm, having another goal or behavior. Other pedestrians were mentioned as third, regarding the amount stimuli the Participants expressed (figure 16). Some Participants perceive other pedestrians as annoying mainly because of their speed. As shown by a 57-year-old male Participant:

"Yes, one thing in the city center is when you're on your way somewhere. Then other people are here, purely with a recreational goal and have no pace."

(...)

"This is of course quite annoying if you want to have a different pace yourself. Because that very slow walking pace just doesn't suit me." (Participant 12)

A similar situation was also experienced by a 32 year old female Participant.

"No, sometimes it's really too busy in the center. (...) That you can hardly move forward, that you are hindered by walking. If you can't get ahead because of the crowds, I find it irritating." (Participant 11)

The situation where Participant 12 is talking about is shown in the figure 21, in this case, a couple with a low walking pace, probably having a day out.

Figure 21: The experience of Participant 12, perceiving other pedestrians with another pace as a barrier



Source: Own creation

Another 28 year old male Participant elaborated on a specific behavior of people at a certain location:

"Well especially that last part on the Turfmarkt, people looking at their phones that you have to avoid. (...) If you compare that to the first part of the walk, it causes a little more stress or something I think." (Participant 8).

The situation is shown in figure 22, a nearly collision with another pedestrian looking at his phone, causing little amounts of stress.

Figure 22: The experience of Participant 12, perceiving a near collision with another pedestrian



Source: Own creation

Very often, tourists or shopping public was called as an annoying factor by the Participants. This relates to a social stressor, crowding. Crowding is increasing people's stress levels if they are limited by their environment (Adli, 2011). This experience of stress, caused by crowding can be explained by the research of Lucas and Solnit (2001). Lucas and Solnit (2001), describe different 'ways of walking' in their research, referring to different types of walking, each with another goal and help to explain the negative emotions that were described by the Participants. The different ways of walking are explained below:

Purposive walking: This way of walking refers to walking with a specific goal in mind, aiming to destination. Mostly with a constant rhythm and at a rapid pace, little awareness about the environment, and mostly with a 'utilitarian' goal. For example: This can be the Participants, walking to their work, aiming at a specific time to reach their work, or shopping for groceries at a specific shop. The focus is on the endpoint, rather than the act of walking itself.

Discursive walking: This refers to walking more spontaneously, varying in rhythm and pace, with complete awareness of the environment. A 'hedonistic' way of walking. For example, a tourist or people having a day off and do some shopping. The focus is on the walking itself, rather than having an (urgent) goal.

Conceptual walking: This refers to walking more reflective, building critical awareness of the environment more artistically. For example: what city planners do, when they want to make plans for a new neighborhood and they visit the neighborhood that needs to be redesigned. The focus is less on the physical act of walking and more on the mental or intellectual processes that occur during the walk.

Figure 23: Example of shopping people with a discursive way of walking perceived by of the Participants



Source: Own creation

Each way of walking has its intention, and sometimes, this can conflict with other ways of walking causing annoyance or stress. For example, someone who has to make their bus in time (purposive walking), can have a conflict with someone who just wants to roam around in the city with a recreational goal (discursive walking). Especially when there is involvement of external time pressure, for example caused by the urge to catch a bus, as mentioned by this 40-year-old male Participant:

"The closer I get, the higher the stress level goes, you know, because I get closer and closer, but: 'What if the bus drives away now'? Then that's super annoying, for example": just before getting in and the bus drives away right in front of me. Another traffic light on the way <Participant referring to the traffic light that prevents the Participant from making the bus on time>... "(Participant 1)

The example of the bus is shown in figure 24, showing the bus far in the distance, and the group of pedestrians, causing feelings of stress.

Figure 24: The experience of Participant 1, seeing the bus far in the back, and getting blocked by pedestrians



Source: Own creation

The experience of external time pressure relates to the *authority constraint* (Hagestrand, 1970). This is an important part of the literature review. Since time schedules are determined by the transport operator, in this case, an authority, this participant is constrained in their daily potential path area, causing stress. In general, the Participants, in this case pedestrians, as a road-user with a low speed, and therefore vulnerable, needed to be vigilant, especially in areas where it was unclear for them to walk. A 52-year-old female Participant was really clear about what could happen if you don't pay attention, and if a car driver does not pay attention to this person:

"That is, of course, if you walk as a pedestrian in places where many motorists are looking for a place. Who doesn't pay attention to you? (...) Then you have to pay extra attention to whether that motorist sees you. Otherwise, you'll just lie underneath it" <referring to a motorist> (Participant 9)

There are certain places, such as the Grote Marktstraat, where at certain times, especially during the afternoon walks, this 48-year-old male Participant also mentioned that he needed to watch out, and it is very busy.

"Well, this is of course the Grote Marktstraat, where there are cyclists, as well as pedestrians and supply traffic. That's busy, just watch out. I know that there are also children cycling, they just cycle through here. In the afternoon (...) it's just too busy" (Participant 10)

This example shows, the more stimuli that are present, the more likely this Participant finds the area to busy. This relates to the stimulus overload theory, which is based on the idea that the numbers, their presence in the space and their diversity can lead to psychological stress causing affective or behavioral responses (Schmidt & Keating, 1979). This 52-year old female and 43 year old Participant amplifies this insight by stating the same area (Grote Marktstraat) as an area with respectively 'chaos' and 'this is too much for me':

"It is, of course, the height of chaos here. (...). I know there's a whole philosophy behind it. But the fact that I don't see anyone crossing here with, for example, a wheelchair or something. Says it's chaotic." (Participant 9).

"What I'm saying, it's people walking and cyclists and car traffic and public transport. Yes, that's too much for me. But that's also personal traits, character, I don't like crowds." (Participant 2)

4.1.3 Obstacles and lack of space for pedestrians

In some cases, there was hardly no space for the pedestrian at all. This was influencing the feeling of a 'sense of security' negatively (Brosschot et al., 2018). This was described as annoying by this 48 year old male Participant:

"What I do find annoying here is that the sidewalk is very narrow, especially when I walk here with the children and you have to pass people, there always has to be someone walking on the bike path." (Participant 10)

Figure 25: The experience of Participant 10, perceived as a lack of space for the pedestrian causing annoyance



Source: Own creation

In some cases, there was no space for the pedestrian at all, creating dangerous situations, causing annoyance by one of the Participants:

"There are an awful lot of cars driving here with quite a relatively high-speed. It goes on and on and you don't have a place where you can cross quietly. That gives a bit of stress that I think all the time when can I go, and then you also have to pay attention to the cyclists because they come at a high speed afterwards (Participant 14)."

Figure 26: The experience of Participant 14, showing there is no space for the pedestrian to cross over, the design is also unclear, one of the most coded topics on environmental stimuli.



Source: Own creation

These conflicts also arise with cyclists or (e-)moped users, no space for the pedestrian. This was experienced by this 57 year old male Participants in the following way (as shown in figure 20):

"The only thing that is annoying in this tunnel is that there is actually no space for the pedestrian. Yes, so what you get is mopeds that come from the front and from the back. And cyclists, especially during rush hour. So you have to pay attention to something that is actually a nice walking route. Too bad there wasn't the space here to do something for the pedestrians.(Participant 13)"

Figure 27: The experience of Participant 13, addressing there is no space for the pedestrian, one of the most coded topics on environmental stimuli.



Source: Own creation

In addition, obstacles such as roadworks or building construction work do not help to make the area more friendly and comfortable for pedestrians, and also adds to the fact that there is not much space in the city center.

"It is of course irritating that a large part of the street is cordoned off, but I understand that they do that, I am not bothered by that now because it is very quiet now. This is a bit like; Everyone wants to be on the street at the same time, and something in me registers that the engine keeps running, and then I think turn it off for a while. It's all noisy (Participant 14)."

According to research of Sarkar et al. (2013), the experience of obstacles or movement limitation such as excessive street slopes can make it difficult for people to move around and access their needs and can induce psychological distress. Some Participants also describe obstacles as a 'bottleneck' creating less space. Referring to pedestrians being forced to walk on a narrow part of the sidewalk causing crowding (Adli, 2011). Examples obstacles are shown in figure 28, 29 and 30.

Figure 28: Example 1 of a 'bottleneck' for pedestrians



Source: Own creation

Figure 29: Example 2 of a 'bottleneck' for pedestrians



Source: Own creation

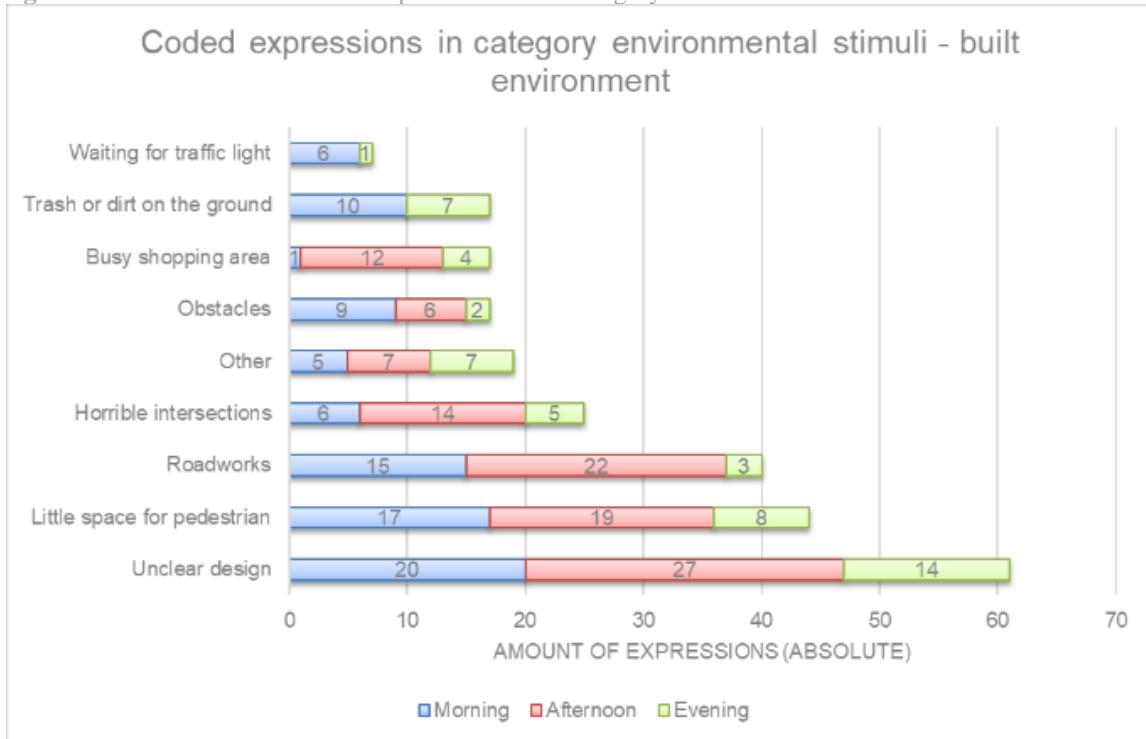
Figure 30: Example 3 of a 'bottleneck' for pedestrians



Source: Own creation

Figure 31 gives a complete overview of all the expressed experiences of the Participants towards environmental stimuli.

Figure 31: Total amount of coded expressions in the category environmental stimuli – the built environment

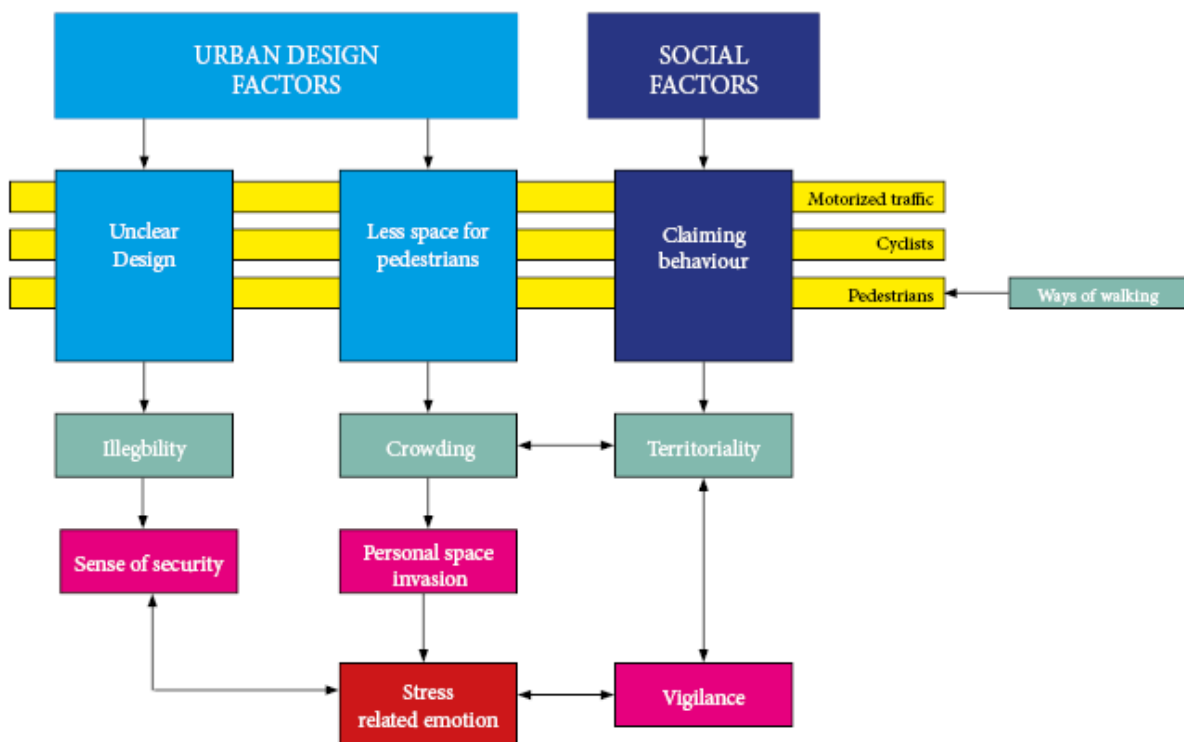


Source: Own creation.

4.1.3 Summary of environmental stressors

The spatial tensions as described in this chapter are a complex interplay of different factors and underlying mechanisms. Figure 32 aims to visualize a theory on how the measured factors relate to each other and eventually induce stress in a highly dense urban environment.

Figure 32: Interplay of different factors of tension in space



Source: Own creation

4.2 Coping mechanisms

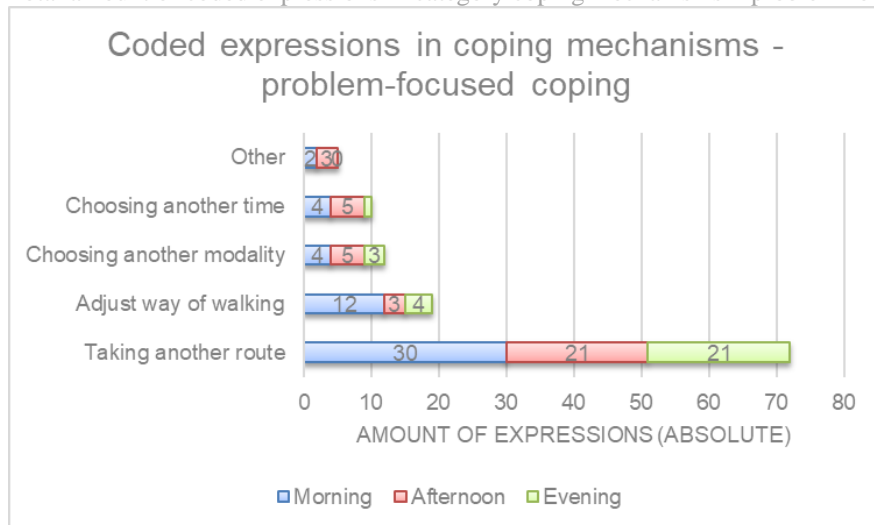
Following the theoretical framework, stimuli are appraised, and when they are appraised as stressful, coping mechanisms come into play. Coping mechanisms aim to resolve the underlying stressor (Cooper, 2007). Despite multiple stressors in the urban environment, the Participants showed resilience during the walk-alongs having developed different coping methods to relieve from stress. Three main coping mechanisms were identified, namely problem-focused coping, emotional-focused coping and future-oriented coping.

4.2.1 Problem-focused coping

The lion's share of the coping mechanisms were problem-focused coping mechanisms referring to 'head-on' action to resolve the underlying cause'.

By far, 'taking another route' is used as a coping mechanism to avoid stressful situations arising from for example, cyclists or other pedestrians, and in some cases, just to be faster at a certain destination. Figure 33 shows the expressions that are categorized in problem-focused coping mechanisms.

Figure 33: Total amount of coded expressions in category coping mechanisms – problem-focused coping



Source: Own creation

An example of a reason why someone uses this coping mechanism is described by this 45-year-old female Participant:

"We are taking a different route now, this morning we came via that path. But I like this one even better because it's a little further away from the busy road. (Participant 14). "

Figure 34 shows the route that was chosen by Participant 14, to avoid a busy road.

Figure 34: The route that was chosen by Participant 14 to cope with a busy road



Source: Own creation

This indicates that this Participant wants to avoid one of the main stressors that was mentioned in the theoretical framework, namely; noise. The next (52-year-old female) Participant got conscious during the interview, that she does avoid busy streets, so she does not have to pay attention to other road-users:

"I did learn a bit about myself. So I do avoid the busy streets, I notice. Not because I find it exciting or scary. But I do find it easier. You don't have to pay attention. Maybe that's it. (Participant 9)."

Besides taking another route, some of the Participants also adjusted their walking tempo while they were walking to avoid a stressor or an encounter, such as a possible collision with another road user. In the following example, this 31 year old Participant said the following after a moment with a lot of traffic:

"Those are also those very small things, do you know that happen all at once? Yes, you make an action. That I was going to walk faster to get out of the crowds quickly or something? (Participant 11)"

In other situations, Participants slowed down, took a pause when a heavy tram passed by, and sometimes they just walked through a mass of people causing crowdedness. This is shown by this 43 year old female Participant:

"Most of the time, I just keep walking in the hope that someone will move aside, and if not, I'll move aside at the last minute. It's a tactic that I developed at some point. Because going around everything was driving me crazy. " (Participant 7).

This coping mechanism was used in the central station area, where during peak hours, a great number of people, sometimes in a hurry, have to leave or enter their train. Figure 31 shows the area where Participant 7 was using her coping tactic.

Figure 35: The central station area where Participant 7 was using her coping tactic



Source: Own creation

Some of the Participants made decisions to choose an alternative transport mode, mostly to avoid bad weather circumstances or just to be quicker to a certain appointment. This 31 year old male Participant has a short note on this:

"When the wind is blowing hard and I know I have a tailwind, I am more inclined to go cycling. " (Participant 3).

Choosing another time, for example to leave the working place, is also used as a coping mechanism by different Participants. This 53 year old male Participant shares the following problem focused coping mechanism:

"You just feel that you can be hit by a car at any moment, which might be a bit too exaggerated. Yes, then I know if I go half an hour or an hour earlier or later it will be quieter. More relaxed, so to speak. Less stressful. " (Participant 2)

Another interesting coping mechanism was the one a 57-year-old male Participant mentioned, this refers to a form of 'symptom reduction' (Edwards, 1992):

"Then I walk with my phone in my hands then I don't have much to do with the surroundings. Kind of shutting myself off from the environment tactics." (Participant 12)

4.2.2 Future-oriented coping

Also, forms of future-oriented coping (Schwarzer, 2002), one of the theoretical concepts in the theoretical framework, were identified during the research, for example, this 28-year-old male Participant told this about future-oriented coping:

"Yes, yes, I am someone who takes that <referring to future-oriented coping> into account a lot. For example, if I saw yesterday, for example, a sidewalk is closed or there are construction works there, I really take a different route, or I take the bike instead of going for a walk. " (Participant 8)

Also this, 57-year-old male Participant took into account future events, used a form of preventive coping (Schwarzer, 2002). He mentioned the following example:

"Often all kinds of things happen at the Ministry of the Interior and Kingdom Relations, that the military police closes off a part of it or something. If I know in advance, that there will be another protest or something, then I will consciously get off at Holland Spoor instead of CS <referring to taking another route>. I can be very annoyed by that. " (Participant 12)

Another interesting choice some Participants chose was to walk through areas where it was more quiet, with less traffic. These Participants' already chosen these routes before a certain stressor occurred. This 53-year-old male Participant used walking to relieve from stress and figure 32 shows the area he chose to avoid stress, liberating himself from the busy city.

" So this is nice, because not much happens here. Then I can let go more easily. (Participant 2)"

Figure 36: The area that is been walked through by Participant 2 to avoid busy parts of the city



Source: Own creation

Or another area (Palace Gardens) that was chosen consciously by this 45 year old female Participant to avoid traffic.

" It's nice, you hear that you have an oasis in the middle of such a city actually. (...) I always try to look them up a bit. Where it's quiet and green (Participant 14). "

Figure 37: The Palace Gardens, perceived by Participant 14 as an "oasis"



Source: Own creation

4.2.3 Emotional-focused coping

This section describes different ways how the participants used emotional coping during stressors on their routes. 11 of the 14 Participants expressed they were familiar with the route they walked, and therefore have already developed coping strategies for different stressors in the city. The degree of habituation is related to the extent to which a person has developed strategies to cope with the stressors. The more someone is habituated the better able someone is to cope with stressors.

Here is an example of a 31-year-old male Participant:

"Sometimes it's also a certain degree of habituation, of acceptance. You live in a city, you walk in a city, then these kinds of things are just part of it." (Participant 4)

This relates to the habituation theory, which is a fundamental concept in psychology (Grissom & Bhatnagar, 2009). Habituation is a process by which an organism becomes less responsive to a repeated stimulus over time. This also relates to the Adaptation Level Theory which also indicates individuals adapt to their environment and circumstances, leading to changes in their perceptions, evaluations, and behaviors over time (Wohlwill, 1974).

Another 32-year-old female Participant puts things into perspective by ascribing the 'hazard' of cyclists in a busy center to the Dutch culture and places her view from a cyclist's perspective:

"It's just part of that Dutch culture, that as a cyclist you just accept that you have to navigate through the crowds. But when it gets really busy, it's dangerous, but then cyclists also listen better. But if you're not used to it and you just come here for a day of shopping. Yes, then very dangerous things can happen, of course." (Participant 11).

Another 48 year old female Participant is so habituated that she was coping with noise to 'filter out' sounds:

"Those cars, I can hear that, but if I want, I can filter that out a bit and then it certainly feels like the sun comes through a bit here so you get a very nice place. " (Participant 14)

This 48-year-old male Participant explains his vision about habituation regarding someone's living environment:

"But the common thread is that I think you get very used to it, to your living environment, that you experience situations that someone else might find very unsafe, that you don't experience as unsafe very quickly, because you just experience it very often.

(...)

I notice that when my parents are visiting us, and I walk through the city with them, they are frightened by every bicycle bell. And when they see homeless people they look up like, hey, you don't have that with us in Apeldoorn?! I don't even notice it anymore..." (Participant 10).

Apeldoorn, mentioned here, is a small town ((492 inhabitants per square kilometer)(CBS, 2023)), a small city center with a lot less stimuli during an ordinary day, compared to The Hague. Adding to this, the same Participant also further explained his vision toward habituation:

"And I, I just know when I walked here in this Saturday afternoon heard that I just shouldn't just blindly cross from the Bijenkorf to the Kruidvat because you have to be careful because cyclists just ride fast through here." (Participant 10)

Habituation also relates to predictability, according to Glass & Singer (1974), predictability in both social and physical environments - knowing the cues, and hence knowing what to expect -tends to reduce stress. On the other hand, the effects of stressors are heightened by the unpredictability due to lack of perceived control.

4.3 Stress reducing stimuli

The former sections shed light on spatial tensions and coping mechanisms. To put some things in perspective, during the start of each walk-along the Participants' were asked what they liked, or what they did not like about their routes. The Participants also liked to elaborate on positive aspects, of the route, solutions, or walking in general. To get started, 11 of the 14 Participants were positive towards walking in general. Some Participants used walking as a form of relaxation- clearing their heads, especially during the afternoon walks, or used walking as a contribution to a healthy lifestyle to lower stress. Appendix 4 shows the coding tree on positive expressions towards environmental stressors.

One of the most common positive expressions towards other people has to deal with the area where the other pedestrians are and in which mood they are or what goal they have. Here is an example of a 45-year-old female Participant referring to other people that were recreating at a square with terraces, lunchrooms, and restaurants:

"You don't have to pay much attention as a pedestrian. It goes a bit automatically and flows past other pedestrians here to the left. It is busy, but people are just sitting on a terrace chatting a bit, and not many people here seem to be in a hurry, it seems everyone is here just to have lunch. " (Participant 14).

Another 43-year-old female Participant amplified that by sharing the following expression:

"I always just like it when there's a bit of hustle and bustle. " (Participant 6).

Figure 38: Example 1 ‘hustle-and-bustle’ area, being perceived positively by Participant 14 and 6.



Source: Own creation

Figure 39: Example 2 of a ‘hustle-and-bustle’ area, being perceived positively by Participant 12



Source: Own creation

Furthermore, some Participants were positive about their route when there were fewer cars or not much traffic. The most positive expressions during the route were ascribed to the built environment. And mainly had to deal with quiet places without traffic, and walking in a nature or park setting. The contribution of natural environments to the reduction of stress has been confirmed by an abundance of research (Gidlow et al., 2016; Groenewegen et al., 2018; Ulrich et al., 1979). If there is a lot of space, and the design is clear (regarding rules in traffic and knowing where to walk), Participants expressed positively. Natural environments that were perceived positively are shown in Figure 40, 41 and 42:

Figure 40: Example 1 of a quiet place with a lot of space for pedestrians perceived positively by participant 13



Source: Own creation

Figure 41: Example 2 of a quiet place with a lot of space for pedestrians perceived positively by participant 9



Source: Own creation

Figure 42: Example 2 of a quiet place with a lot of space for pedestrians perceived positively by participant 1 and 8

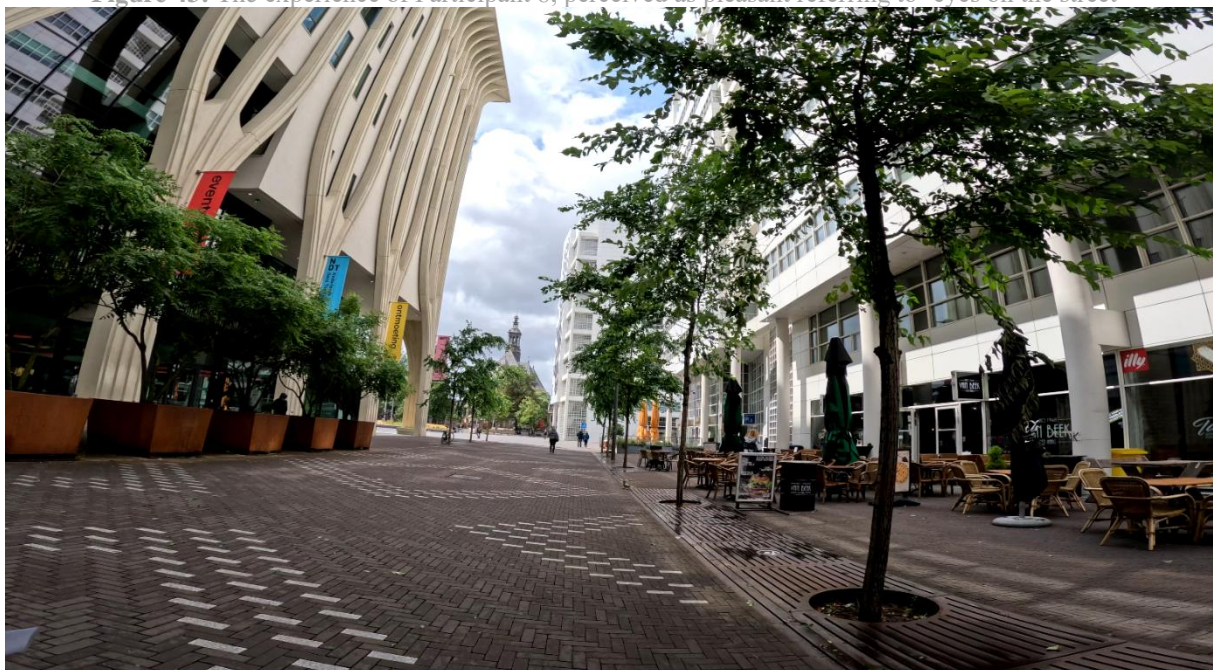


Source: Own creation

Amenities on the route, for example, to run an errand on their way home or to provide a feeling of safety, as described by this 28-year-old male Participant is also an important aspect mentioned by different Participants:

"Well you can also see here on both sides that the plinth ground floor is filled with catering and retail, that gives a pleasant feeling, doesn't it, that you know of.... That you have eyes on the street or something?" (Participant 8)

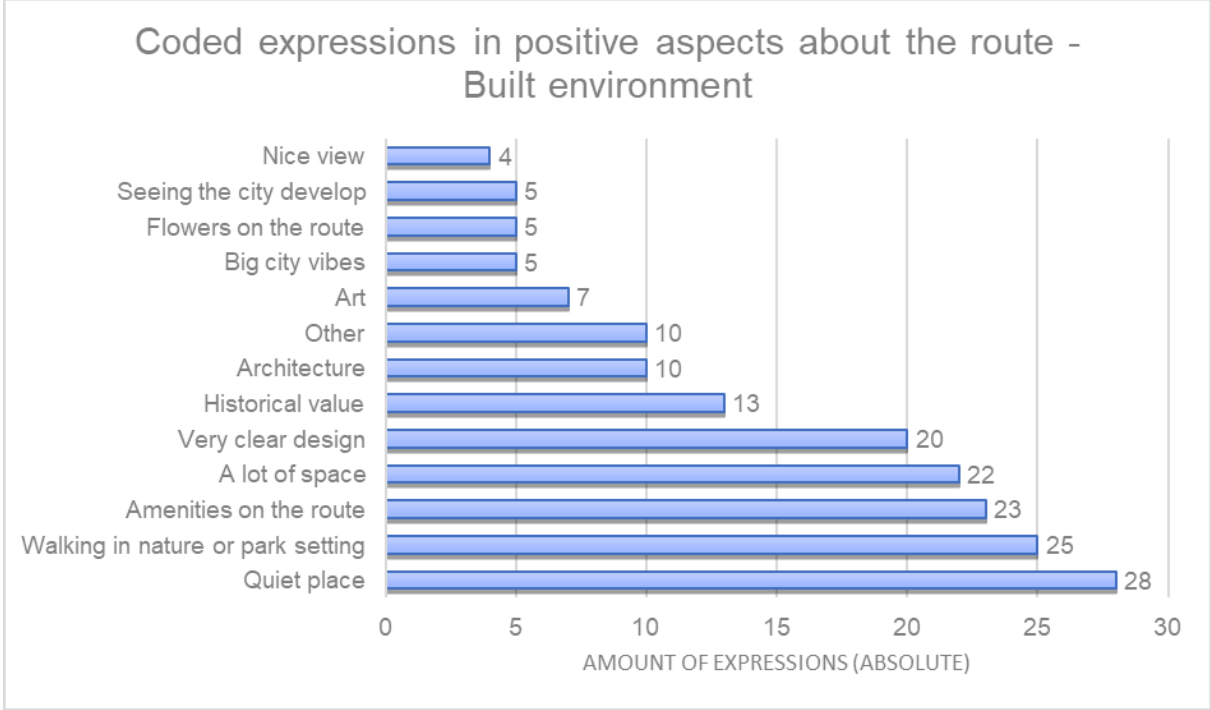
Figure 43: The experience of Participant 8, perceived as pleasant referring to 'eyes on the street'



Source: Own creation

The aforementioned expression regarding safety due to amenities relates to the work of Jane Jacobs (2015), who suggested that vibrant street life and access to amenities contribute to feelings of safety by increasing natural surveillance and social interaction. To have an overview of all positive coded expressions in the category built environment, see figure 44.

Figure 44: Total amount of coded expressions in category positive aspects about the route – Built environment



Source: Own creation.

5. Conclusion

As urban populations continue to grow, dense urban environments have become characteristic of modern cities (European Environment Agency, 2014). City planners are increasingly seeking sustainable solutions to preserve livability (Mindell, 2018). Policies promoting active modes of travel, such as walking and cycling, aim to foster an active lifestyle and reduce pollution. The COVID-19 pandemic has prompted reconsideration of travel behaviors, raising questions about commuting to work. Urban environments are associated with higher levels of stress and mental health issues compared to rural areas (Peen et al., 2020; Johansson et al., 2011; Adli, 2011; Heinz et al., 2013; Hosang, 2016). The objective of this research was to describe and explain insights on walking commuting stress due to the urban environment, to cope with rising levels of urbanization, and a higher level of stress prevalence in these areas together with policies that promote an active way of commuting. To this end, the following main research question was formulated:

How do different factors in a high-density urban environment affect momentary stress-related sensations of people on their walking commute to work?

This study focused on how different factors in a high-density urban environment affect momentary stress-related sensations of people on their walking commute to work. The study took place in the central area of The Hague, a highly-dense urban area with around 11.000 people per square kilometer (CBS, 2023). 14 Participants (7 male and 7 female) were invited to join a walk-along research during the commute in the morning rush hour, evening rush hour and during an off-peak moment in the afternoon. The participants could choose their routes freely and express their thoughts about their environmental experiences during their walks. All the walk-alongs were recorded with a GoPro Hero11 Black video camera. The next section answers the aforementioned main research question.

5.1 Main findings

According to the literature, pedestrians are commonly affected by environmental stressors such as *crowding* (Gifford, R., 2007; Evans, G. W., & Cohen, S. 2004; Loo, R. 1977), *climate change* (Halpern, D., 1995; Mazlomi, A., et al., 2017; Cianconi, P., et al., 2020; Gruebner, O., et al., 2018), *noise* (Glass, D. C., & Singer, J. E., 1972; Zhang, M., & Kang, J., 2005; Kamp, I., & Davies, H., 2023), *air pollution* (Tzivian, L., et al., 2015; Bakolis, I., et al., 2020; Hanna, R., et al., 2019), *visual pollution* (Allahyari, M. S., et al., 2017; Dargahi, S., & Rajabnezhad, M., 2014; Hassell, S., 2014), *safety perception and crime rate* (Cultrona, T. A., et al., 2006). The walk along study identified all environmental stressors to a greater or lesser extent that could be attributed to the aforementioned categories.

The main findings of the research reveal various spatial tensions that induced stress among the participants, particularly in shared space areas (Beitel et al., 2018). The spatial tensions comprise a complex interplay between different social and urban design factors. The first factor touched upon the behavior of space users. During travelling, frequent conflicts arose between the Participants and cyclists as both groups endeavored to claim specific areas in space relating to territoriality (Hall, 1969). These conflicts led to negative emotions among the Participants, including annoyance, irritation, and stress. This situation was exacerbated by less space for pedestrians and unclear designations for pedestrian pathways and, in some cases, a complete lack of space for pedestrians to walk causing crowding (Steg and De Groot, 2018). In areas with less motorized traffic or cyclists, conflicts arise due to differing walking speeds and styles of pedestrians. This indicates the presence of different pedestrian groups with varying goals and speeds, such as tourists exploring the city versus individuals rushing to catch a bus. In general, since the participants were pedestrians, they were vulnerable and therefore had to be vigilant in these kinds of areas. Being vigilant, especially for longer times can contribute to stress and exhaustion (Hopstaken et al., 2014). This answers sub-question 1; *Which environmental stressors can be identified during the Participants' walking commute to work?* The second sub-question aimed on coping mechanisms; *How do coping mechanisms play a role in dealing with stress during the Participants' walking commute to work?* The participants exhibited resilience during the walk-alongs, employing various coping methods to alleviate stress. The coping mechanisms exhibited by the participants are categorized into problem-focused coping, emotional-focused coping, and future-oriented coping (Lazarus, 1966). Regarding problem-focused coping

mechanisms, participants often opted to take an alternate route to avoid particular stressors. In some cases, Participants' adjusted their way of walking, to speed up or slow down to avoid a stressor. At times, participants chose alternative transportation modes or adjusted their travel times to avoid stressors. In addition to primary coping mechanisms, Participants had specific coping strategies that were effective for them. It stands out, that acceptance as an emotional-focused coping method, and eventually habituation plays an important role in the height of the stress the Participants' were experiencing and the level they already developed coping mechanisms (Grissom & Bhatnagar, 2009). The more the Participant was used to living or working the city the less stress the Participant experienced, for example describing the stimuli as something that 'just' belongs to a big city relating to the Adaption Level Theory (Wohlwill, 1974). *Which individual differences of Participants play a role in the perception of stressors and coping mechanisms?* The research showed that Participants' who mentioned they were highly sensitive expressed almost twice as more stress related emotions than participants who were not (Aron, 1996). Furthermore, female Participants showed slightly more stress related experiences compared to male Participants.

Additionally, this research also gained insights in stress-relieving factors. Mainly natural environments such as parks are described as stress-relieving (Gidlow et al., 2016; Groenewegen et al., 2018; Ulrich et al., 1979). Other stress relieving places are that were experienced positively by Participants naming it 'hustle-and-bustle' created a higher sense of security (Brosschot et al., 2018; Ward Thompson et al., 2016). Furthermore, quiet places with no or less traffic was ascribed by the participants as stress-relieving and sometimes liberating. Lastly, a clear urban design for pedestrians, which is perceived as safe and with amenities on the route were mentioned as the most stress-relieving factors during the walk-alongs.

5.2 Discussion

The findings of this research are mostly in line with the literature and are particularly strong by adding insights by combining different stress theories, multiple environmental stimuli, as well as coping mechanisms in an *on-site* walk-along situation. The stress experienced by the Participants regarding other users such as territoriality in claiming of space or other ways of walking relate to the invasion of personal space and therefore crowding (Steg and De Groot, 2018). Different ways of walking relates to the work of Lucas and Solnit (2001), who described different types of walking. This research adds on the work of Lucas and Solnit, suggesting different ways of walking can also lead to conflicts between different groups or pedestrians, leading to more invasion of personal space, and therefore stress. The combination of the different tensions in space, leads to an exacerbation of stress related emotions. This is in line with the environmental load theory, which is based on the idea that overload (i.e. deriving from urban stressors) denotes peoples inability to process inputs from the environments because there are too much inputs to cope with causing stress (Milgram, 1970). The combination of 'claiming space' behavior and an 'unclear design' leading to stress contributes to the existing literature. The aforementioned insight adds to the fact that there is relatively little research on the effect of multiple stressors in urban environments and how they may interact (Tzivian et al., 2015). Furthermore, this adds to the fact that most of these kind of studies were done in a lab, whereas this study focused on momentary perception of stress on an on-site and real-life environment (Wang et al., 2016; Sherif Samir Elrafie et al. (2023). The stress that arises from an unclear design, aligns with the literature on legibility. Legibility in urban design influences the sense of security and safety, and therefore is decreasing stress and anxiety (Brosschot et al., 2018; Mccay et al., 2017, Tabatabaian & Tammannaee, 2014). An illegible urban design works the other way around. The coping strategies that were discussed are in line with primary coping strategies suggested by Lazarus (1966). Habituation, as an important outcome that indicates stress reduces over time relates to the habituation theory, which is a fundamental concept in psychology (Grissom & Bhatnagar, 2009). Habituation is a process by which an organism becomes less responsive to a repeated stimulus over time. The finding that natural environments contributes to the reduction of stress has been confirmed by an abundance of research (Gidlow et al., 2016; Groenewegen et al., 2018; Ulrich et al., 1979). The stress-reducing effect of "hustle and bustle" relates to align with the literature regarding a 'a sense of security' indicating that being part of other people can alleviate from stress (Brosschot et al., 2018; Ward Thompson et al., 2016).

This study tried to address the scientific need to gain more insight into momentary stress *on-site* experiences in an urban environment and how multiple environmental stressors interact. The findings mostly align with existing literature and provide valuable insights by combining stress theories, environmental stimuli, and coping mechanisms.

5.3 Recommendations

5.3.1 Future research

With several unanswered questions, this research has different possible starting points for further research. This research is done during the summer season. It could be interesting to do the research during different seasons. For example, a comparison of stress experience between winter and summer times (Halpern, 1995, Mazlomi et al., 2017, Cianconi et al., 2020). Furthermore, the majority of studies on mental health in urban areas have been conducted in developed countries, however, many of the world's most stressful cities are located in undeveloped or developing countries therefore it is advised to focus future research on developing countries (Sadeghpour et al., 2024). This research focused mainly on highly-educated, native Dutch and people with no physical impairments. Future research could focus on different education levels, different ethnic backgrounds or vulnerable groups, such as HSP-persons or persons that have troubles with processing stimuli (Aron, 1966). Mainly because the research showed that Participants' who mentioned they were highly sensitive also expressed almost twice as more stress related emotions than participants who were not. Furthermore, female Participants showed slightly more stress related experiences compared to male Participants. This study focused purely on environmental stressors, and did not take into account stress in someone's personal life, it could be interesting to see how environmental stressors interact with other kinds of stressors for example induced by work or home situations (Sadeghpour et al., 2024). Regarding urban design, it could be interesting to study how the theme 'unclear design' can be resolved. Which aspects make an area 'unclear' (Brosschot et al., 2018; Mccay et al., 2017, Tabatabaian & Tammannaee, 2014). Furthermore, habituation is a clear theme that affects the way how stress is experienced in highly dense urban environments, future research could dive into habituation and the length people are living in the city, and to which point certain environmental stressors start getting less stress inducing (Grissom & Bhatnagar, 2009). In general, a quantitative survey could be done to validate and strengthen the outcomes of the research. Other research methods, such as biotechnical ways of measuring stress such as measuring cortisol levels (Roe et al., 2013), skin conductivity (Layeb et al., 2016), EEG tests (Aspinall et al., 2015), or Heart Rate Variability (HRV) could complement the qualitative findings on environmental stressors for future research directions if there is enough funding available. Lastly, the enriched transactional model of stress (conceptual model) can be reused to structure future research on environmental stressors (Lazarus, 1966).

5.3.2 Policy recommendations

Many European cities aim towards more active ways of travel, such as cycling and walking to promote an active lifestyle and create more livable cities with more space and less pollution (Mindell, 2018). This research has identified several issues that contribute to more or less stress for a pedestrian. This research shows that following main issues induce stress during a pedestrians' commute; unclear design, claiming behavior of different road users and less space for pedestrians. The following key points must be taken up by the municipality of The Hague to make their city less stress inducing for their pedestrians:

1. Raise awareness between different road users to be more tolerant and less self-centered (short term)

The research shows that road users seem to claim rights of different parts in space and therefore frequent conflicts exist. Tolerant behavior can play an important role in mobility in a daily urban system. To make some city dwellers more aware about possible egocentric behavior on a short term, a campaign can make them more aware of their behavior and stimulate them to share space together. Possible name for the campaign: "Sharing space is caring".

2. Transform current shared space areas to an urban design that is legible and coherent for pedestrians (mid term)

This research indicates that stress mainly occurs in the shared space areas in the city center of The Hague, raising questions about the suitability of this concept in a city with a rapidly growing population. Legible urban design leads to less stress and anxiety, thus promoting a more friendly and walkable urban environment (Tabatabaian & Tammannaee, 2014). Different shared spaces could be designated to create an integrative and coherent design, rather than an ambiguous and illegible one. The selection of these areas could be improved by incorporating traffic safety data, such as the number of accidents.

3. Prioritize space when there is lack of space for pedestrians (short to mid term)

The Hague, as a city in development, has many construction sites. Often, the continuity of car traffic is prioritized when a road is blocked, leaving little space for pedestrians and forcing them onto the road, creating unsafe and stressful situations. During roadworks like these, and in general urban design, there should be more space allocated for pedestrians to minimize conflicts with other users. In this way, safety and crowding can be reduced to minimal levels (Steg and De Groot, 2018).

4. Create more green spaces that function as a buffer that can alleviate stress for pedestrians (mid term)

This research shows once again that green spaces alleviate stress (Gidlow et al., 2016). The current urban design in the inner city of The Hague has low amounts of green spaces that can serve as a buffer to alleviate stress. It is suggested that the Municipality of The Hague creates more green zones, mainly in the inner city.

5. Try to take into account different pedestrian groups when planning new functions in the city (long term)

The inner city of The Hague attracts substantial amounts of visitors every day. Every pedestrian has its own way of walking, varying from goal oriented walking, to a more discursive way of walking. Or even a conceptual way of walking, for example if the walking is needed to observe an object for example work. By planning different functions according to the meaning of the area, pedestrian groups can be better aligned creating less stress and more 'hustle-and-bustle'.

6. Grow towards an inclusive design (long term)

This study shows that different groups can experience greater problems with stress experience than other groups. For example people that who highly sensitive, elderly coping with trauma from a concussion or other kind of impairments. Taking into account these kinds of groups, can help create more inclusive design to invite more vulnerable pedestrian groups as a measure on a longer term.

Appendix

1. Guidelines walk-along research

SEMI-STRUCTURED INTERVIEW

The main goal of the guidelines for the walk-along research are to make sure the right data will be extracted. The walk-along study will be an open conversation, possibly asking questions to gain more insights in the experience of stress of the participant during that walk and what that induces. In the process, the researcher – participant interaction of asking questions fades into the background, in favor of rather a conversational encounter between two people (Bibi, Ehgartner, 2021). The parts in 'BEFORE THE WALK-ALONG' and 'AFTER THE WALK-ALONG' are compulsory but not meant to push the participants towards a certain direction. During the walk-along it will be a more flexible and adaptive way of researching. The goal is to provide the participants the right comfort and empathy to ensure they will share their thoughts and feelings during the research. If any input arises after the walk-along study (for example; an comment or idea later on), this will be used in the research.

BEFORE WALK-ALONG

Instructions:

This study is about the experience of stress in high density urban environments during a walking commute to work. The goal is to gain more insights in how stress arises due to the urban environment and how you experience this. During the walk-along study i will mount the Go-Pro camera to capture possible stressors and enrich the data of this research.

You decide which route we take. The goal is for you to describe the route, what you experience and how you deal with it. What do you like / dislike about the route and why is that, these can be smaller or larger things. Feel free to think out loud. What do you see, hear, smell or feel? You can also rate an experience.

Goal: Informing the participant about the study, what they could expect and giving them a sense of focus during the walk along research.

1. How do you feel right now?

Goal: Capturing a possible base-level of stress. This could emerge when the first part of the participants' journey was in public transport for example.

DURING THE WALK-ALONG

Environmental stimuli

<when experiencing a potential stressful stimuli>

1. How do you feel right now?
2. On a scale from one to ten, how stressed do you feel after this experience?
3. Can you describe the route, and what you experience?

Coping

<observing if someone tries to cope with this stressor>

1. Can you explain what happened right now?

AFTER THE WALK-ALONG

1. Was this route familiar to you?
2. Why did you take this route?
3. What do you like about this route?
4. Do you feel less or more stressed after this walk?
5. Do you experience any other stressful events during your walking commute to work?
 - a. If so, what did you experience?
 - b. Did you try to find a solution for the stressful situation?
6. Do you have any other things you want to share?

Thanks a lot with helping with the interview. I appreciate this a lot!

Other possible helpful questions:

1. Do you take different routes when you observe possible stressful events?
2. Do you make different decisions when you know there will be stress on the route?
3. Do you feel more stress when there are more stressors?
4. Do you feel less stressed when you are walking with someone?
5. Have you accepted certain earlier stressful experiences?
6. Have you got used to (acclimated) to earlier stressful experiences?

2. Informed consent form



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The Netherlands
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Informed consent form

Educational project:

Master Human Geography
Thesis
Utrecht University

Researcher's name: Marc van der Burg

Supervisor's name: Dr. Elisa Fiore

Purpose of this study:

With increasing urbanization, cities are becoming more and more crowded. Policymakers are looking for sustainable solutions to improve the quality of life in cities. For example, by encouraging walking and cycling in cities as an alternative to the private car. It has been proven that in cities the mental state is less compared to rural areas, in which stress plays an important factor. The aim of the research is to describe and explain insights about stress when walking commuting due to urbanization, coupled with policies that promote an active way of travelling.

Your cooperation:

For my study programme, I am working on a thesis for which I collect data through 'walk-along research'. During the walk-along study, the journey will be recorded with a GoPro camera. When you approve, the GoPro camera is attached to your waist to capture the surroundings. The video recordings will be worked out in transcriptions at a later date. This data will be handled with care, and will be processed anonymously. This data will be destroyed after completion of the study (no later than August 2024). If you wish, the data that will be published can be shared with you in advance for your consent.

The intention is to do the research in (1) the morning rush hour, (2) during a 'lunch-walk' or 'break moment' and (3) evening rush hour. I walk with you from your neighborhood or public transport location to the office location, and from the office location to your home address. During our walk together, I will ask you about your experiences and thoughts. You will be in the lead during this walk-along. During the walk-along survey, you always have the choice not to answer, pause or stop a question. If you subsequently request the collected data to be deleted, this will be done immediately. If you have any complaints or questions about this study, you can always contact us using the details at the top of this letter.

By signing, you indicate that you agree to your participation in this educational project. Even after signing, you can still opt out of your cooperation.

Of course I hope you will join us, thank you in advance for your cooperation.

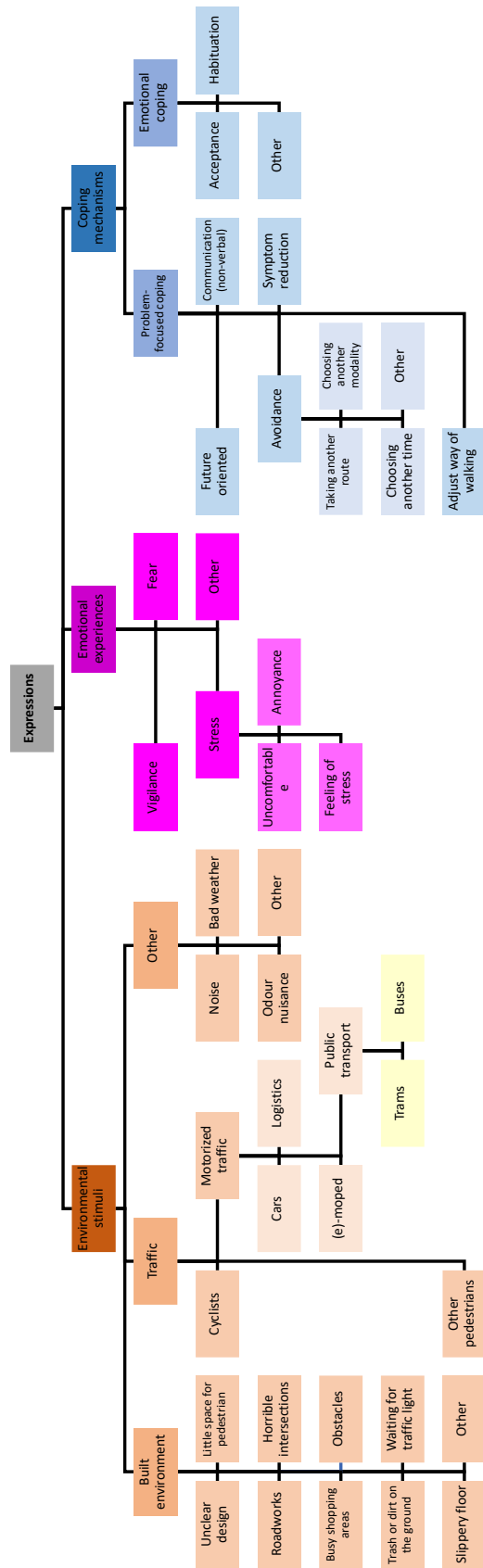
I consent to participate in this study,

Name: Location:.....

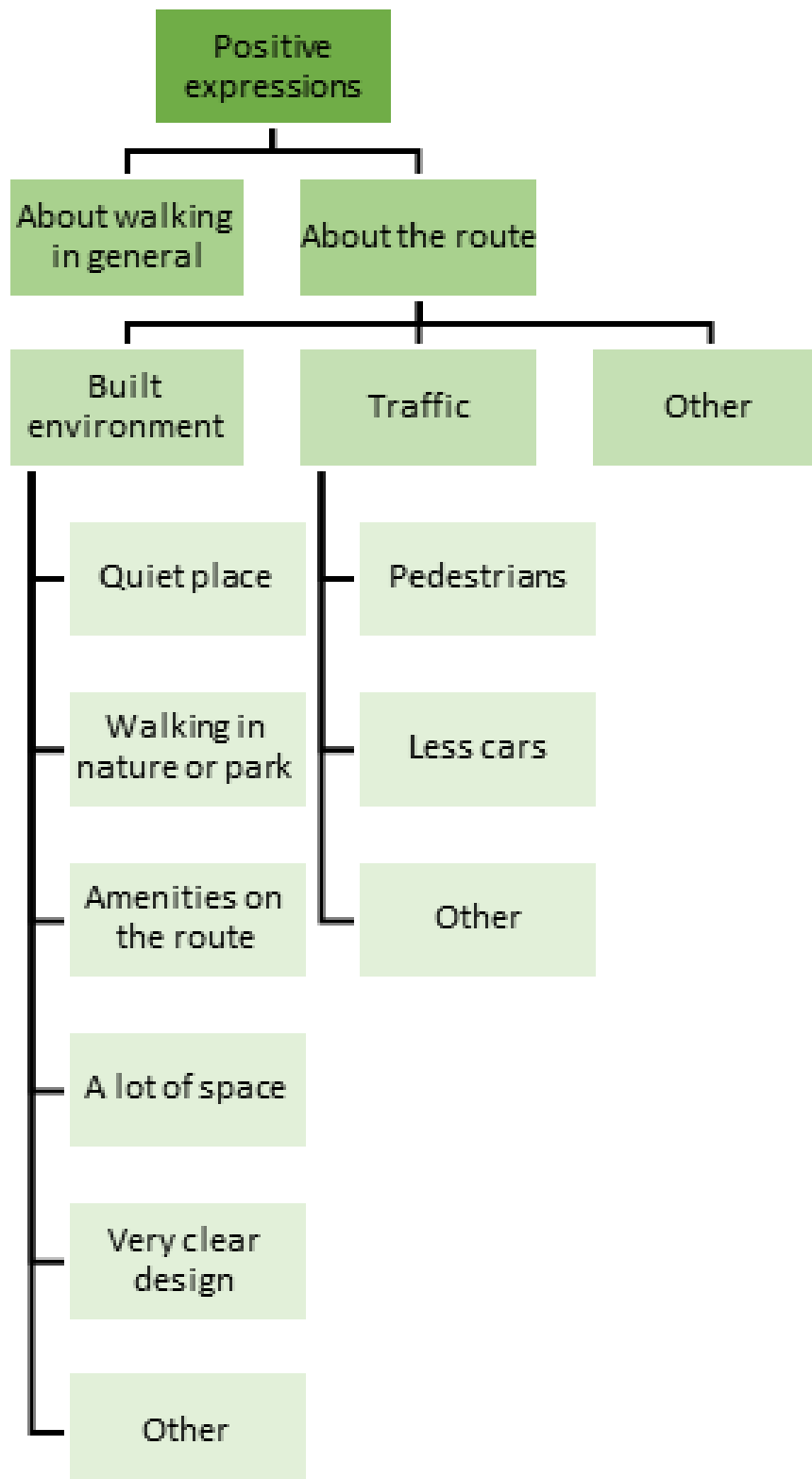
Data:

Signature:

3. Code tree 1



4. Code tree 2



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