Exploring Nature's Influence on the Olfactory Urban Landscape Experience

An explorative research on the influences of urban nature on the urban smellscape experience and preference and possible contributions of the olfactory perception of nature in the urban living environment on wellbeing

Roald Daniël Nooijens

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Swedish University of Agricultural Sciences, SLU
Faculty of Natural Resources and Agricultural Sciences
Department of Urban and Rural Development
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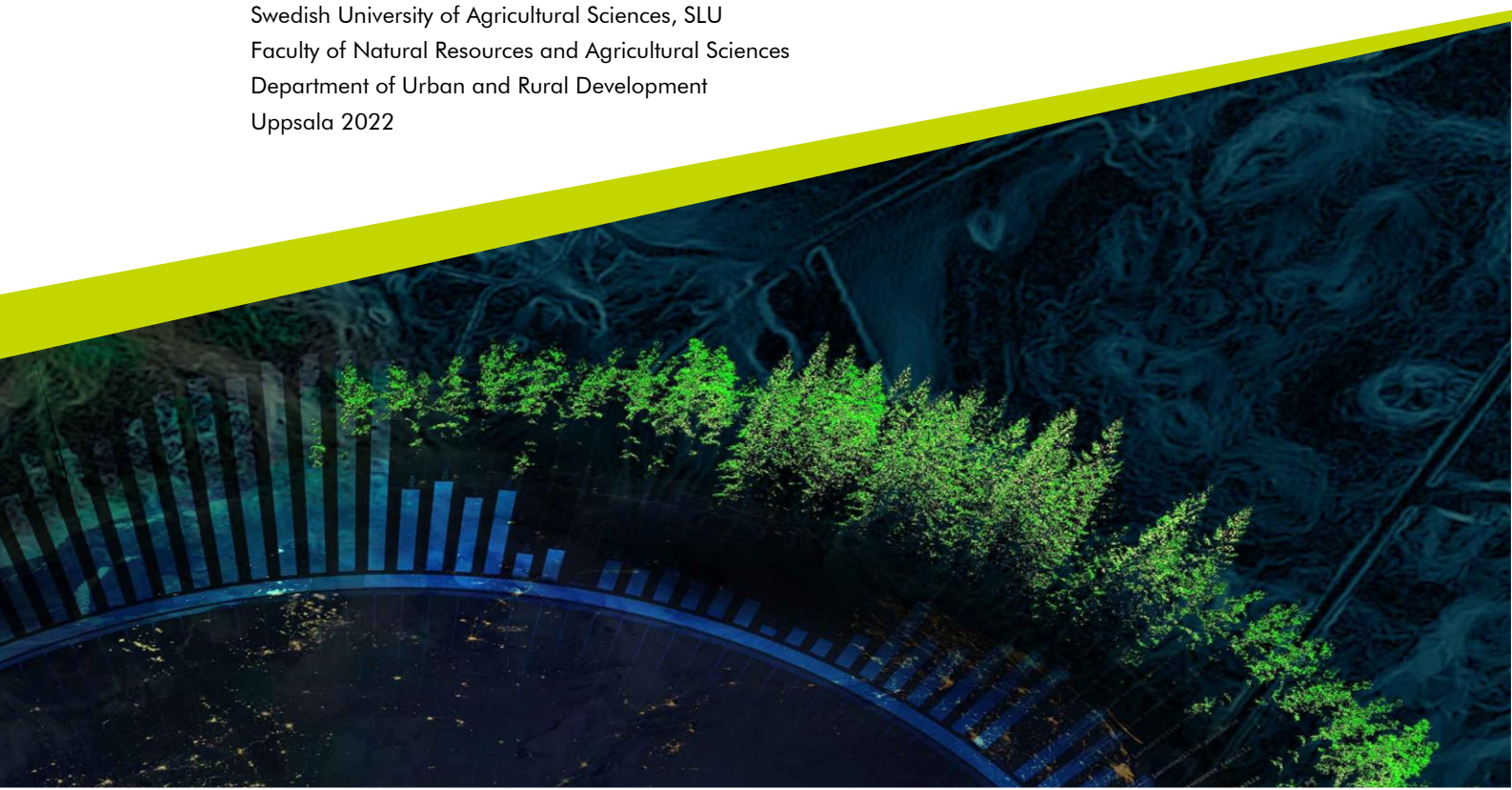

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Roald Daniël Nooijens

Supervisor: Marcus Hedblom, SLU, Department of Urban and Rural Development
Assistant supervisor: Jana Verboom, WUR, Environmental System Analysis group
Examiner: Andrew Butler, SLU, Department of Urban and Rural Development

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Swedish University of Agricultural Sciences
Faculty of Natural Resources and Agricultural Sciences
Department of Urban and Rural Development
Division of Landscape Architecture

Abstract

Impairment of mental wellbeing in urban areas can be explained through landscape experience. Interactions with urban nature have found to positively influence wellbeing through landscape experience. However, research has focussed on the sense of vision, while humans are multisensory beings in essence. The role of olfaction in everyday experiences of people has received too little attention. This explorative study focusses on the influences of urban nature on the olfactory urban landscape experience and wellbeing. A mixed methodology of semi-structured interviews and questionnaires was used to understand perceived olfactory quality and olfactory landscape experience. Participants clearly experienced the olfactory environment different with urban nature present. It was found that urban nature positively influences perceived olfactory quality and increases the positive affective responses to the olfactory environment. Judgement of smells were largely based on associations. Smells of nature were associated with health, freshness, higher environmental quality, and evoked feelings of calmness, happiness and a feeling of being away from the city. Smells of nature contributed to olfactory landscape preference through the evocation of positive effective responses and fostering an experience of nature. Further, smells of nature evoked many deep memories, resulting in positive judgements and feelings. However, further research in different cultural, temporal and spatial contexts is necessary to agree with, adjust or refute the perceptual patterns found. Above all, my study provides new insights in the olfactory dimension of multisensory landscape experience and human-nature interactions and opens a call for more in-depth and in-situ research to multisensory landscape experience.

Key words: olfaction, olfactory experience, multisensory environment, experience of nature, landscape psychology, landscape experience, landscape preference, urban planning.

Preface

The warmth came no earlier than April and uncovered the green underneath the seemingly everlasting blanket of snow that had dominated the landscape surrounding Trondheim for months. My first Nordic winter was colder, darker and longer than I was prepared for, so I opened my arms to welcome Spring. In the glorious sun I cycled up the hills, to the forest breathing again after the frost. On my knees I took a handful of soil, still cold and moist, and smelled it. The smell of forest, the smell of fungi, the smell of life. How I missed the smell of life!

It was only after months of working on my masters' dissertation, talking about it with my friends, that I began to realise my topic of choice was no coincidence. Upon reflection triggered by the literature and interview data I read, I became aware of the role of smell in my own life as well. How the smell of pines consistently gives me the feeling of freedom in Summer times. How I can get annoyed by strong perfume as if it is music too loud.

The olfactory experience of nature. I consider it a synthesis of my academic interests: ecology, philosophy, perceptual constructs, above all human-nature interactions. The latter always has been the core of my academic endeavours, motivated by the deep belief that humans and nature should live more intimately to foster both human and non-human wellbeing. Eventually consolidating in urban nature, or as I see it: bringing nature into the living environment of people.

First of all, I want to thank my first supervisor professor Marcus Hedblom, for getting me into his research on multisensory urban nature experience and, more importantly, for providing the open and intellectual space in which science could be practised based on passion, quality and open-mindedness – in other words: how I think science should be practiced. Without him, the research topic now so dear to me would not have crossed my path and I enjoyed working with him.

Secondly, my thanks go to my second supervisor dr. Jana Verboom, who was in closer spatial proximity to me and always there to help me with all my specific and sometimes arbitrary questions. Thirdly, I want to thank Luna van der Straaten, my partner in life, for listening and reacting to all my conceptual, intellectual and personal reflections and concerns, supporting me throughout the process.

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Abbreviations

GY	Locations with few or none elements of nature
SM	Locations with elements of nature
GN	Locations being an urban park
SoP	Sense of Place

1 Introduction

Urbanisation has various advantages, such as better health care (Dye, 2008) and its (assumed; Turok, 2017) link with development and prosperity (Ravallion, 2007). However, urban life is increasingly associated with a decreased quality of life and impairments of health and wellbeing (WHO, 2021; Francis et al., 2012; Galea & Vlahov, 2008; Frick et al., 1986). Negative effects on health and wellbeing range from behavioural changes, leading to e.g. obesity and violence, to a bad environmental quality, caused by e.g. the urban heat island effect and air pollution (see full overview in review by Galea & Vlahov, 2008). Jackson (2003b, p.1382) describes the urban living environment as imposing 'the nation's greatest current public health concerns.' Since the proportion of the human population that is residing in urban areas is expected to increase up to 70% in 2050 (United Nations, 2018), these problems remain major challenges for the coming decades (Almenar et al., 2021; Keivani, 2010; Brockerhoff, 2000).

1.1 Mental wellbeing and the cityscape

The impaired mental wellbeing of the urban population is one such urban challenge (WHO, 2021). The urban living environment can seriously affect its residents' mental wellbeing negatively (Brighenti & Pavoni, 2019; Lecic-Tosevski, 2019; Abbott, 2012), for instance by causing stress and depression (WHO, 2021; review by Rautio et al., 2017; Peen et al., 2010), which are found to occur independently from socio-economic status (Weich et al., 2002).

1.1.1 Physical elements of the cityscape

Researchers have increasingly recognised the link between *the physical urban landscape*, from now on called: cityscape, and the wellbeing of urban residents (Hadavi, 2015; Velarde et al., 2007; Jackson, 2003a, 2003b) – or as Thompson (2011) found, rediscovered the link, since it had been an important one in earlier times and across cultures. Many physical elements of the cityscape have an influence on wellbeing, among which buildings (Frumkin, 2003), building density (Hur et al.,

2010), vegetation (Hur et al., 2010; Frumkin, 2003), pavement (Kweon et al., 2010), landscape features such as openness (Lee et al., 2008), street trees (Hunter, 2011), upkeep (Hur & Nasar, 2014), transport infrastructure (Krizek, 2003) and the design of urban parks (Peschardt & Stigsdotter, 2013). In fact, the quality of the physical living environment is one of the main factors influencing people's quality of life, hence their wellbeing (Aragonés et al., 2017; WHO, 1998).

The quality of the physical living environment (in the context of human wellbeing) can be measured using instruments and scientifically established standards or by using subjective variables based on residents' own perceptions (Aragonés et al., 2017; Gifford, 2007; Bonaiuto & Fornara, 2004). Previous research showed that the quality of the living environment as perceived by the residents themselves significantly influences their health and wellbeing (Kyttä et al., 2011). In fact, it seems that the *perceived* physical environment is a better predictor of residential satisfaction, perceived health and perceived quality of life than objective measures (Parra et al., 2010; Wen et al., 2006; Ellaway et al., 2001; Van Poll, 1997). As such, cityscape elements contribute to wellbeing specifically through neighbourhood satisfaction (Mouratidis, 2020; Parkes et al., 2002; Fernandez & Kulik, 1981), a sense of community (Kim & Kaplan, 2004), the perceived environmental quality (Vemuri et al., 2011), the perceived healthiness of the environment (Frumkin, 2003), the evocation of positive emotions (Abraham et al., 2010), and stress reduction (Peschardt & Stigsdotter, 2013; Abraham et al., 2010).

Hence, the design of the cityscape can, through various physical elements and their link to people's perception of the environment, constitute either an urban living environment that negatively affects mental wellbeing (Hadayi, 2015); or an urban living environment that positively affects mental wellbeing and behaviour (Abraham et al., 2010; Matsuoka & Kaplan, 2008). Therefore, the link between urban planning and design and health should be strengthened (Thompson, 2011; Jackson, 2003b) in both research and policy (Velarde et al., 2007) to create a living environment that promotes health and wellbeing (WHO, 2017, 2016; Barton & Grant, 2013; Corburn, 2004).

1.1.2 Landscape experience and preference

The perceived quality of the living environment can be studied through landscape experience and landscape preference. As theorised by Kaplan and Kaplan (1989; Nasar, 1989), landscape preference results from satisfaction of people's needs in the landscape and the perception of elements and functions that are meaningful to them (Clark & Uzzell, 2006; Kaplan & Kaplan, 1989; Berlyne, 1974). As such, preferred landscapes represent environments in which human needs are fulfilled and wherein humans function more effectively - without people being necessarily aware of the underlying satisfaction of needs and corresponding cognitive processes (Kaplan & Kaplan, 1989). Non-preference for landscapes on the other hand, is linked to evocation of stress by landscape elements (Hadayi, 2015; Kaplan & Kaplan, 1989).

Whereas Kaplan & Kaplan (1989) claim that humans have an innate landscape preference formed by evolutionary psychological development, Jacobs (2006) argues convincingly that landscape preference is (at least partly) individually and culturally determined. Jacobs (2006) assigns a fundamental role to the subjective landscape experience in people's landscape preference. In his attempt to conceptualise a comprehensive theory on landscape experience, he divides landscapes in a matterscape and a mindscape, being the physical landscape and the subjectively experienced landscape respectively. The mindscape, Jacobs (2006, p.233) says, is 'an active construction created by the complex neural processing of matterscape stimuli that results in an experience that supervenes on a dynamic core of cortical neutral activity[, and its] qualities [...] depend greatly (but not exclusively) on the properties of the incoming matterscape stimuli, the properties of the appraisal mechanisms and the properties of the mental concepts employed.'

Thus, landscape preference is, according to the theory of Jacobs (2006), resulting from a sum of emotions and interpretations of emotions that are evoked by the objects within the matterscape, either directly through biological reactions or indirectly through individually or culturally acquired concepts, norms and values. Research by Galindo & Rodriguez (2000) also showed that landscape preference is constituted by affective responses on physical stimuli. Studies have suggested that pleasantness and beauty are the most prominent dimensions of the affective responses in landscape/environmental assessment leading to preference (Yang & Kang, 2005; Nasar, 1989 and references therein).

In short, by understanding landscape experience and preference and applying this knowledge in urban planning, the cityscape's design can answer people's need and evoke positive affective responses, which is key to inducing health benefits such as stress reduction and restorative effects (Hadayi, 2015; Abraham et al., 2010; Kaplan & Kaplan, 1989). As such, landscape preference has indirect relationships with wellbeing through landscape experience (affective responses), perceived environmental quality and satisfaction of needs. (Although an explicit relationship between landscape preference in itself and wellbeing has been studied scarcely, but see e.g. Van den Berg et al., 2007 for a study on a direct relationship.) Therefore, understanding landscape experience can be considered crucial in designing a cityscape that promotes wellbeing (Verma et al., 2019; Jackson, 2003b).

1.1.3 Nature for wellbeing in urban landscapes

Research in landscape experience and preference has shown time and again that natural landscapes and urban landscapes containing green elements are preferred over urban landscapes without green elements (Lee et al., 2015; Kaplan, 2001; Kaplan & Kaplan, 1989; Ulrich, 1979). Nature or green elements in the cityscape also contribute to neighbourhood satisfaction (Hur et al., 2010; Lee et al., 2008).

Indeed, studies showed that the interactions with nature in the living environment have positive effects on mental wellbeing (van den Berg et al., 2015;

Hartig et al., 2014; Maas, 2006) and the lack of such interactions in the cityscape is proposed as a reason for decreased mental wellbeing (Cox et al., 2018; Soga & Gaston, 2016; Hartig et al., 2011; Miller, 2005; Hartig et al., 2003). It is suggested that interactions with nature reduce negative and enhance positive emotions (Berto, 2014), decrease anxiety (Bratman et al., 2015), reduce mental fatigue, anger and stress (Hartig et al., 2014; Berto, 2014; Hartig et al., 2003), and recover cognitive functioning (Bratman et al., 2015; Berto, 2014; Berman et al., 2008). Furthermore, nature based recovery (spending time in nature) after mental illness has shown to be effective (Sidenius et al., 2017a; Sidenius et al., 2017b; Pálsdóttir et al., 2014). Following these results, urban nature has received much attention as a remedy against stress and decreased mental wellbeing in the urban living environment (WHO, 2021, 2017, 2016).

Despite the well-established evidence that (urban) nature contributes to human mental wellbeing, the mechanisms through which these effects occur remain largely unknown and understudied (Franco et al., 2017; Hartig et al., 2014; Keniger et al., 2013). The Experience of Nature has been postulated as a concept to explain the positive effects on wellbeing, which would be constituted by different contact pathways, among which sensory contact (Clayton et al., 2017; Lumber et al., 2017). Lately, physiological measurements are increasingly being conducted to reveal if subjective perceptions of urban and natural landscapes are also linked to physiological reactions such as lower heart rates (Hedblom et al., 2019).

1.2 Multisensory landscape experience

Many (urban) landscape experience studies, either in-situ or through photographs, have concluded that visual contact with nature in the cityscape has restorative effects (Ulrich et al., 1991) and contributes to cognitive recovery (Lee et al., 2015), stress reduction (Gladwell et al., 2012; Leather et al., 1998) and improved mood (Van den Berg et al., 2003; Kaplan, 2001). Studies were also able to distinguish which physical elements of urban parks influence people's preference and perceived restorativeness based upon visual representations of cityscapes (Peschardt & Stigsdotter, 2013; Hur et al., 2010; Ode-Sang et al., 2009). However, other senses have been studied poorly.

1.2.1 Visual dominance

Indeed, research on landscape experience and preference and interactions with nature in the landscape have been dominated by the sense of vision (Verma et al., 2019; Franco et al., 2017). The scientific course of human sensory experience, urban planning and environmental psychology have been studied through vision almost solely throughout the decades (Hutmacher, 2019; Dowling et al., 2018). This could be seen as a paradigm deeply rooted in western philosophy of the mind and aesthetics that puts vision on the pedestal as exclusive for the enlightened human being (Tafalla,

2014; Fisher, 1999). Besides, using visual imagery instead of in-situ methods makes doing research more convenient and controllable (Kaplan & Kaplan, 1989). However, the visual dominance in landscape experience research can be considered a shortcoming, since the human is a multisensory being in essence, hence experiences the landscape, urban and natural, through all senses.

The dominance of the sense of vision in landscape experience studies can also be considered a shortcoming according to the theory of Jacobs (2006) described before. The landscape experience and preference, which can contribute to mental wellbeing, is constituted in the first place by perceptions of and affective responses to physical stimuli in the landscape. Sounds and smells are physical stimuli as much as visual stimuli. Therefore it should be explored if sound and smell also influence the landscape experience and preference.

1.2.2 The sense of hearing and smell

In that light, recent research has emphasised the multisensory contact with nature in the living environment (Colléony et al., 2020; Hedblom et al., 2019; Franco et al., 2017). For instance, Wooller et al. (2016) found that exclusion of either of the senses decreases nature's contribution to health, and Hedblom et al. (2019) found that auditive and olfactory stimuli trigger neurological responses in VR landscape experience. It is not so much a critique on the visual paradigm, rather a realisation and acknowledgement of the human multisensory essence.

The sense of hearing has been researched by studying people's perception of soundscapes – the auditive dimensions of the landscape, all sounds present in the environment – in the living environment (e.g. Jeon & Jo, 2020; Hong & Jeon, 2013; Lam et al., 2010), although not as much and in-depth as the visual landscape (Verma et al., 2019). Soundscape research is also done in the context of restorative landscapes (Krzywicka & Byrka, 2017), contact with nature (Franco et al., 2017; Fisher, 1999) and its potential positive influence on wellbeing (Ratcliffe et al., 2016; Cerwèn et al., 2016; O'Conner, 2008; Yang & Kang, 2005). Natural soundscapes are often preferred over man-made soundscapes, especially the sound of birds, water and rustling leaves (Ratcliffe et al., 2013; Schwarz, 2013; Irvine et al., 2009). Furthermore, it is suggested that natural soundscapes can contribute to the stress recovery properties that nature has (Cerwèn et al., 2016; Annerstedt et al., 2013; Alvarsson et al., 2010; Payne, 2013).

The sense of smell however, has remained largely understudied (Verma et al., 2019; Franco et al., 2017). Smell (also named scent, odour, fragrance) in the living environment has almost solely been studied as nuisance needed to be deodorised (Rodaway, 1994). Again, reasons therefore are found in a deeply rooted scientific paradigm: smell was associated with lower forms of consciousness, as opposed to enlightened human intelligence. This philosophical debate formed the early practice of neuroscience (McGann, 2017). It led to the belief that human olfaction was rather weak, but the opposite appears true (Laska, 2011), since smell influences emotions,

memories, behaviour and communication more directly than the other senses (McGann, 2017; Chen & Haviland-Jones, 1999).

1.2.3 The importance of smell

Olfaction - both the sense of smell and the process of smelling - is truly a crucial component of the multisensory mundane experience of people. Rodaway (1994) argued that the sense of smell and its effects on people's everyday social and emotional experiences in cities is highly underestimated. Indeed, for people suffering from anosmia, the lack of olfaction, life in general decreases in (aesthetic) appreciation, as was found in the collective narratives from people by philosopher Tafalla (2014; 2013). Tafalla's inquiries are backed by science revealing that lacking the sense of smell decreases one's quality of life and increases the occurrence of depressions (Croy et al., 2014; Frasnelli & Hummel, 2005; Miwa et al., 2001; Todrank et al., 1995).

Acknowledging the importance of smell in the experience of everyday life, some urbanists (McLean, 2019; Quercia et al., 2016; Henshaw 2013; Henshaw et al., 2009) and architects (Kapur, 2020; Spence, 2020a, 2020b) showed interests in the olfactory experience in relation to the management and design of the living environment and wellbeing. All emphasize the lack of research on and understanding of human olfactory experience of the urban living environment.

1.3 Olfactory experience in the cityscape

It is important to elaborate on the olfactory experience (of nature), since it goes beyond just the sense of smell – the detection and identification of an odour. Olfaction includes many physiological, neurological and psychological mechanisms (Xiao et al., 2018). As Auffarth (2013, p.1668) formulates it, 'smell is not an intrinsic property of odorant molecules, but a perceptual phenomenon', and to understand human olfactory functioning fully, both neurological processes and olfactory perceptions should be considered.

1.3.1 Olfactory perception

Psychophysical research showed that the human olfactory organ is impressively good at detecting and discriminating smells (Yeshurun & Sobel, 2010; Zelano & Sobel, 2005 and references therein) and odour mixtures (Cain, 1977), even at very low concentrations (Whisman et al., 1978). After detecting a smell, the olfactory system's cortical components translate the odorant molecules into a perception of the object (Wilson et al., 2014). The olfactory perceptions are coloured by individual genetics and experiences and cultural factors, making olfactory perception a highly subjective process (Rodaway, 1994).

Notwithstanding the great abilities of the olfactory organ, humans generally have great difficulty naming the smells they detect, especially without the help of labels (Zelano & Sobel, 2005). This is due to the olfactory system's cortical components being poorly connected to the cortical components that enable perceptions to be translated into lexical interpretations (Olofsson & Gottfried, 2015) – in other words: humans often have difficulty putting their olfactory perceptions into words. However, this inability does not limit people's affective responses to smells (Yeshurun & Sobel, 2010).

The olfactory perception is suggested to be dominated by the affective response in terms of pleasantness and arousal, also named the hedonistic dimension (Engen, 1982). Yeshurun & Sobel (2010) and Khan et al. (2007) concluded based on earlier research (Zarzo, 2008; Schiffman et al., 1977; Schiffman, 1974; Berglund et al., 1973), that *pleasantness* is the primary axis of describing olfactory perceptions. Substantial affective response in terms of pleasantness occurs even without the perceiver being able to describe the olfactory perception in lexical constructs (Yeshurun & Sobel, 2010).

Olfactory experience is known to be dominated by evocation of emotions and associations (Krusemark et al., 2013), due to the cortical proximity and strong neurological links between the cortical components that regulate olfaction and cortical components for processing emotions (Kohler et al., 2007). As a consequence, smell can strongly influence mood (Soudry et al., 2011), and olfactory perceptions can evoke instantaneous deep memories, known as Proustian memories (Horowitz, 2011; Parker et al., 2001; Price, 1985). The memories evoked by olfaction are more intense and emotional than those evoked by other stimuli (Sugiyama et al., 2015; Herz & Schooler, 2002; Herz & Von Clef, 2001) and it is said that positive autobiographical memories evoked by olfaction have a positive effect on mood and a reducing effect on stress (Herz, 2016).

1.3.2 The smellscape experience

The landscape, just as it contains a soundscape, contains a smellscape as well: the totality of background smells and foreground smells in both space and time (Porteous, 1990). Smellscapes are the olfactory dimension of the landscape – or cityscape. Different than the auditive and visual perception, human olfactory perception lacks the ability to correctly locate smells (Sela & Sobel, 2010). Diaconu (2011) describes smellscapes as having atmosphere-like properties, meaning that smellscapes are hard to grasp, yet being present in it, one relates to it. To integrate the olfactory dimension in urban management and planning for wellbeing, it is necessary to understand the olfactory dimension of people's landscape experience (Xiao et al., 2018).

Smells as physical stimuli in the cityscape may trigger emotions, associations and memories: affective responses to olfactory perceptions. As such, the smellscape may be part of people's in-situ landscape experience as conceptualised by Jacobs (2006) and people's perception of environmental quality.

To my knowledge, the first and only scientific attempt to develop a framework for understanding smellscape experience has been conducted by Xiao et al. (2018). The perceptual model they formulate assumes that pleasantness is the key dimension in smellscape experience. An assumption in line with theory described in sections 1.1.2 and 1.3.1, since pleasantness is said to be a dominant dimension both landscape experience and preference (Yang & Kang, 2005; Nasar, 1989 and references therein) and olfactory perception (Yeshurun & Sobel, 2010; Khan et al., 2007 and references therein).

Xiao et al. (2018) found that olfactory pleasantness in urban smellscapes is indicated by nine olfactory qualities: freshness, calmness, liking, appropriateness, naturalness, intensity, purity and familiarity. Furthermore, Xiao et al. (2018) found that pleasantness can be determined by: preferences of smells versus nuisance of smells; healthiness associations; memories evocation by the smells; and appropriateness of the context in which the smells occur.

1.3.3 Nature in the urban smellscape: the knowledge gap

Xiao et al. (2018) found that naturalness is an indicator for smellscape pleasantness, suggesting that similarly to the preference for visual and auditive landscapes, smellscapes with elements of nature are preferred. This suggests that the olfactory perception of nature is a sensory contact pathway contributing to a positive affective response to the landscape and wellbeing (Franco et al., 2017). Also the smellscape studies by Quercia et al. (2016) and Henshaw (2013) found that natural elements in the urban environment were judged pleasant relative to other smells, but so did smells of bakeries and perfume. None of these smellscape studies truly studied the effect of nature on the urban smellscape experience.

Several studies found that nature-related odours evoke positive feelings and reduce stress, for instance: lavender odour was found to relieve stress (Toda & Morimoto, 2008); chrysanthemum to reduce vigour (Kilonzi et al., 2019); lavender and orange smell to reduce anxiety and improve mood (Lehrner et al., 2000); floral scents to improve mood and cognitive functions (Jo et al., 2013); natural smells to be perceived as more pleasant (Glass et al., 2014); and 'green' odours were linked to reduced stress hormones (study on rats by Fujita et al., 2010). An experiment conducted in a virtual reality simulation of urban nature found that smell in particular had a large effect on stress responses in subjects, more so than visual and auditory stimuli (Hedblom et al., 2019).

These results also suggest the smell of nature in the urban landscape being able to evoke positive affective responses. As such, smells of nature possibly contribute positively to the perceived quality of the living environment, hence to landscape preference and wellbeing. However, all these studies have been conducted with artificially induced olfactory stimuli, therefore they are not representative for the everyday experience of the cityscape.

Several studies on smells of nature have been done with natural olfactory stimuli: Pálsdóttir et al. (2021) found that the olfactory perception of nature has a role in nature based recovery in garden smellscapes; Weber and Heuberger (2011) found an evocation of positive emotions in a fragrance garden; and forest smell is considered an important element in the therapeutic effects of Japanese forest bathing (Hansen et al., 2017; Park et al., 2010). Again, these studies are not representative for the everyday experience of the cityscape and/or did not focus on the smellscape experience at large.

The results from above mentioned studies open a call for a better understanding of the olfactory perception of (urban) nature (Franco et al., 2017) and its role in landscape experience, as a potential pathway through which nature contributes to a wellbeing-promoting urban landscape (Hedblom et al., 2019). To do so, there is a need for in-situ studies on olfactory perception of urban nature, since these are likely to differ from experimental studies (Cadena et al., 2017) and have not yet been done (Truong et al., 2020).

1.4 Purpose of this study

This study, as the first to do so to my knowledge, explores the in-situ olfactory perception of urban nature and its contribution to urban landscape experience. The aim of this research is to contribute to the understanding of how urban nature contributes to an urban living environment that promotes human wellbeing through landscape experience and preference, by exploring the in-situ olfactory perception of different urban green settings and the contribution of this perception to smellscape preference and human wellbeing. The following research questions were guiding:

RQ1. What influences does urban nature have on the urban smellscape experience?
- RQ1a. Which olfactory elements does urban nature bring into the perceived urban smellscape?
- RQ1b. What influences does urban nature have on the interpretation of the perceived urban smellscape through associations?
- RQ1c. What influences does urban nature have on the feelings evoked by the urban smellscape?

RQ2. To what extend does urban nature contribute to urban smellscape preference?
- RQ2a. Which elements of the urban smellscape are perceived as pleasant?
- RQ2b. What influences does urban nature have on the evaluation of the urban smellscape?

RQ3. To what extend does the olfactory experience of urban nature contribute to a landscape that fosters wellbeing?

The methodology of yielding data to answer these research questions is elaborated in detail in chapter 2. Chapter 3 and 4 present results on olfactory environmental quality

evaluation and self-perceived momentary wellbeing respectively. Chapter 5 provides an overview of the smells perceived, described and judged by the participants. A thematic analysis is elaborated in chapter 6. The results from chapters 3 to 6 are discussed and interpreted in chapter 7, before answering the research question in the conclusion, to be found in chapter 8.

2 Methodology

Data to answer the research questions was yielded using a mixed methodology of semi-structured interviews and surveys. The relatively new method of smellwalking was used (Henshaw, 2013), adjusted to fit the purposes of the study. The mixed method provided both semi-quantitative data from scales and qualitative data from interviews. Section 2.1 and 2.2 briefly elaborate on the participants and the ethical concerns respectively. Section 2.3 explains the theoretical approach: phenomenology. Section 2.4 and 2.5 elaborate in detail on the data collection and analysis respectively.

2.1 Participants

The study, being for a large part qualitative, had no predefined amount of participants (Kumar, 2011). Instead, it was aimed for to arrive at saturation of the data. A hybrid form of saturation was used, combining data saturation and inductive thematic saturation (Saunders et al., 2018). Data saturation is a stage wherein new qualitative data from participants is repetitive and not adding new information (O'Reilly& Parker, 2013) – which can already occur at 13 interviews (Francis et al., 2010; Guest et al., 2006). Inductive thematic saturation focusses on the analysis of data and holds that saturation is achieved when new interviews do not lead to new codes and/or themes (Birks & Mills, 2015). Saturation is a process rather than a single point, as Saunders et al. (2018, p. 1901) note that 'the analysis does not suddenly become ''rich'' or ''insightful'' after that one additional interview, but presumably becomes richer or more insightful.' Therefore, it was chosen to go somewhat 'beyond saturation' to be sure of saturation and gain more conceptual depth (Saunders et al., 2018).

Participants under 18 were excluded from the study, based on the assumption that non-adults experience and formulate their experience in a different manner. Participants were recruited through snowballing: the first participants were recruited from the circle of acquaintances of the researcher and each participant was asked to volunteer another participant for the study, who was contacted afterwards. The participants were all Dutch and inhabitants of the city wherein the data collection took place.

The study included 26 participants, with 50% male and 50% female. Age of the participants was distributed over a wide range, but highly skewed towards younger people (14 between 18-25; 4 between 26-35; 1 between 36-45; 2 between 46-55; 3 between 56-65; 2 between 66-72). Education level of participants was distributed over low to high educational background, with a skew towards higher education, with 54% having had academic education (bachelors degree (4), masters degree (9) and PhD degree (1)), and 46% had non-academic education level (high school (1), practical education (4) and applied sciences (7)).

One participant's data had to be excluded from data analysis, since he recently had a covid infection and still had a complete absence of his sense of smell. Therefore, he could not observe anything olfactorily. Consequently, the study had 25 participants for data analysis.

2.2 Ethical concerns

The study aimed at yielding data that include both emotions and memories that can be personal and sensitive. Therefore, the participants were asked for consent for the data collection before the interview. This means that: 'the participant must be competent to give consent; sufficient information must be provided to allow for a reasoned decision; and consent must be voluntary and uncoerced' (Schinke & Gilchrist, 1993, p.83).

In order to do so, the participants were informed about the research topic and the possible personal nature of the data. They were ensured that all data will be handled fully anonymously, since no name will be documented and only a number will be labelled to their data. The participants were ensured that only I will listen to the recording and that only transcripts may be shared with other academics. Lastly, the participants were told that they may stop the interview whenever they want and that nothing is expected from them. After informing the participant, they were asked consent orally: 'do you voluntarily want to participate in the study?'; and 'do you agree the data is shared among academics?'. If both questions were answered positively, the interview started.

2.3 Theoretical approach

Data on the olfactory landscape experience is based on subjective perceptions in essence (see introduction; Jacobs, 2006). Developed frameworks to study the smellscape perception do not exists yet as they do for visual landscape and soundscape perception. Only one attempt has been made by Xiao (2016) and Xiao et al. (2018), however this framework is not yet sufficient to investigate the olfactory perception in depth (Xiao et al., 2018). Hence, relying solely on the existing questionnaires had the danger of missing important subjective perceptions. Therefore,

besides using Xiao et al.'s (2018) framework, the study used a phenomenological approach to collect in-depth data on the subjective perceptions.

2.3.1 Phenomenological Approach

Jacobs (2006) states that mindscapes – the subjectively experienced landscape – are by definition constructed by subjects. Therefore, a phenomenological approach is suitable (Seamon, 1982), especially since the research topic has not been studied much (Davidsen, 2013). Phenomenological methods attempt to explore the subjective experience of people as such, without models available (Davidsen, 2013; Smith & Shinebourne, 2012; Smith et al., 2009). They allow to examine the subjective experience on a detailed level – for example the experience of the awareness of the sun's warmth when one touches the cold water (Eatough & Smith, 2008) – and the meaning of experiences in one's life (Smith et al., 2009).

Interviewing is a common method to use in phenomenological research. Interviews allow to study people's experience of the world, thoughts and feelings in more depth than questionnaires and quantitative methods (Berg, 2007; Kvale, 1996). Interviews result in a description of the subjective experience in people's personal language (Davidsen, 2013). Language can be considered the source of knowledge on people's emotional and personal experience par excellence (Tuan, 1991). Through language, experiences can be communicated – despite the fact that language can never grasp experience completely (Jacobs, 2006). Therefore, interviews "provide an effective way to explore and understand the ambiguous and complex human experience of smellscape" (Xiao, 2016, p.48). In line with this theory, the current study used interviews to explore the olfactory experience of the urban landscape.

2.3.2 Smellwalking as a methodology

Smellwalking will be used to analyse the in-situ olfactory experience of the participants. According to Degen & Rose (2012), the subjective sensory experience of the environment in everyday life is constituted in part by the act of walking itself. Therefore, Degen & Rose (2012) say that walking as a methodology enhances validity of in-situ data. Smellwalking is said to analyse people's experiences of everyday life (Holmes & Hall, 2020) from a more-than-visual perspective (Dowling et al., 2018) and could therefore be used in urban planning (Allen, 2021; McLean, 2019; Henshaw, 2013; Henshaw et al., 2009).

During a smellwalk, the perceiver and researcher walk through a landscape and focus on the present smellscape. Through a semi-structured interview the perceiver explains his/her olfactory experiences (Adams & Askins, 2009; Adams et al., 2008). As such, smellwalking focusses on both the perception of smell as well as the substances present in the environment (Xiao et al., 2018). Analysis of smellwalk data results in an overview and assessment of the smellscape as perceived by the people, and gives insight in the olfactory dimension of the landscape experience.

2.4 Data collection

An earlier smellscape study by Xiao (2016, p.iv) concluded that participants from different cities cases 'had similar perceptual processes and evaluation criteria'. With that in mind, the data for the current study was collected in three different Dutch cities to maximise participation with the limited resources available for the study: Wageningen, Utrecht and Middelburg. Each participant performed a smellwalk along three transects while partaking in a semi-structured interview. At the end of each transect, the participants were asked to fill in a questionnaire to assess the overall olfactory quality of the location.

2.4.1 The smellwalk locations and routes

In order to answer the research questions – on the effect of urban nature on the perceived urban smellscape and smellscape preferences – three different categories of urban smellscapes were used for comparison. Grey smellscapes (GREY) functioned as a baseline, representing cityscapes with very few to none urban green elements. The second category of cityscapes, named SEMI, contained elements of urban nature without being an urban green area. The third category of cityscapes, GREEN, represented an urban park. As such, the olfactory landscape experience in two cityscapes with different degrees of urban nature could be compared with each other and the GREY baseline smellscape. Appendix I shows photos of the locations.

The criteria used to choose the locations are discussed in the subsequent sections below. These criteria were considered essential both to capture the characteristic of the urban setting with a certain amount of green and to maximise both visual and olfactory similarity among the three cities to ensure comparability. The locations were close to the cities' centre for two reasons: city centres have a great variety of settings close to each other, among which urban parks; and it is convenient for all participants to come to the locations by themselves.

2.4.1.1 Baseline: location GREY

The location GREY (GY) represented the cityscape with as few green elements as possible. The following criteria were used to choose GREY locations:

- There are no or very few green elements along the transect. Transect does not go through an urban green space and only goes through built up area.
    - A few single trees or other plants may be present along or near the transect, as this is hard to rule out in Dutch cities. As long as these green elements remain exceptions.
    - Only around these single trees or other plants the soil may be without pavement, aside from that all soil is sealed (by pavement, concrete or asphalt).

- The transect does not go through the cities' shopping centre to prevent the participant perceiving a great amount of smells from e.g. perfumeries, bakeries, restaurants, shops and so on, as this will lead to noise in the data.
    - One to five café's or stores may be present along or near the transect, as this is hard to rule out close to the city centre.
    - Other buildings should dominantly function as private housing or office buildings.
- The location is within the older part of the city, therefore the visual aspect is characterised by historical buildings. Dutch historical architecture is very typical, see appendix I.
- There is no busy, asphalted car road along the transect, to prevent a dominant smell of exhaust gasses and cars.
    - It is hard to find a transect without cars, since they are parked everywhere throughout the cities in the Netherlands except for the shopping centres. Therefore, a transect with little traffic was chosen.
    - GY is within a 30 km/h zone, which means slow driving cars and narrow roads. Usually, there is no asphalt, but pavements in these zones.

2.4.1.2 Green elements: location SEMI

The location SEMI (SM) represented a cityscape with separate green elements, such as grass, trees and other plants, without it being an urban park. The following criteria were used to choose the SEMI locations:

- The location is still (visually) dominated by buildings, such as a row of houses on both sides of the road that forms the transect. The location is clearly built-up area.
- Along at least 75% of the transect, green elements are present in the form of grass, trees or other plants. Green elements that need to be present are at least:
    - Multiple trees
    - Small patches or a larger patch of grass or open soil
- The soil is still dominantly sealed, except for the places where the green elements are situated, and participants predominantly walk over pavement.
- There is a water body near the transect, no more than ten meters away. (This criterium was added, because the first city where the study was conducted had a water body that was olfactorily perceived. To maintain comparability, it had to be present in all three SM locations.)
- There is no busy, asphalted car road along the transect, to prevent a dominant smell of exhaust gasses and cars.
    - It is hard to find a transect without cars, since they are parked everywhere throughout the city in the Netherlands except for the shopping centres. Therefore, a transect with little traffic was chosen.

- Following, location SM is within a 30 km/h zone, which means slow driving cars and narrow roads. Usually, there is no asphalt, but pavements in these zones.

2.4.1.3 Urban park: location GREEN

The locations GREEN (GN) were situated in an urban park or another large and continuous urban green space. The following criteria were used to choose the GREEN locations:

- Natural elements such as shrubs, trees and grass (visually) dominate the location. The transect continuously goes along green elements and never leaves the urban green space.
  - Buildings may be visible at the border of the urban park, as this is hard if not impossible to prevent in Dutch urban parks.
  - Other man-made elements, such as trash cans, little fences or benches may be present.
- The soil is predominantly unsealed. The walkway may be sealed, but along the walkway soil needs to be bare or be covered with grass, other plants or leaves.
- No motorised vehicles are allowed to enter the park.
- There is a water body somewhere in the urban park, at least visible while walking. (This criterium was added, because the first city where the study was conducted had a water body that was olfactory perceived. To maintain comparability, it had to be present in all three GREEN locations.)

The exact vegetation composition of the GREEN locations differed for each city. The urban park in Middelburg had more shrub vegetation, whereas the park in Utrecht had more trees. See appendix I for visual representation of the locations.

2.4.1.4 Routes

A transect of 5 minutes walking was set-out in each location, along where the actual smellwalks were conducted. The locations were randomised for each participants, to prevent any form of bias possibly occurring when following a specific order of locations. In reality, these transect took anything from 4 to 9 minutes, depending on the walking pace of the participant and length of the interview answers. The locations were on a three-minute walking distance from each other, in order to make the total duration of the interview as short as possible, hence maximising the convenience for participants. Appendix I shows the routes set out in the different cities.

2.4.1.5 Weather conditions

The study was conducted in the Netherlands during autumn, in the period of the 14th of October to the 22th of November 2021. Climatic conditions in this period were typical for autumn in the Dutch temperate climate. Day temperatures ranged from 5°C to 15°C in a normal distribution (KNMI, 2021), with most day temperatures being around 10°C over the whole period and over all location. Only a few days were

perceived as truly "cold" by the participants. Around half of the days were sunny and half of the days it was cloudy or completely clouded, a few days it was drizzling a bit, and on one day it was raining.

2.4.2 Personal information

Before the smellwalks, participants were asked to fill in some personal information to get an overview of the research population. Additionally, some information was collected that could be related to the data on the participants' olfactory experience. Furthermore, the sensory perception of nature could be influenced by self-perceived nature connectedness (Truong et al., 2019), which was obtained by the self-nature scale as developed by Schultz (2002; used by Truong et al., 2019; Prévot et al., 2018; Liefländer et al., 2013). Furthermore, smoking habits and a recent infection with COVID-19 (or another medical cause) were noted, since these could impair the sense of smell and therefore have influenced the data. Besides, the current self-perceived mental wellbeing was asked. See box 1 for the personal data as asked to the participants and appendix II for the survey as presented to the participants.

Box 1. Questions before smellwalk to gather personal data of the participants.

1. What is your gender?
   a) Female
   b) Male
   c) Other
   d) Prefer to not say

2. What is your Age?
   ……

3. Do you smoke on a regular basis?
   Yes/No

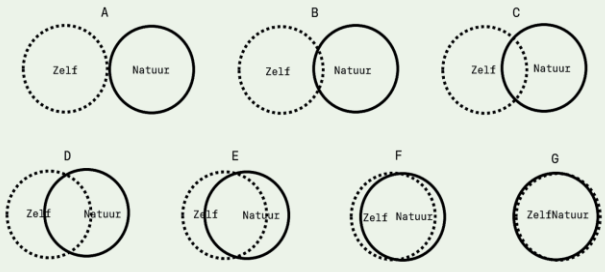
4. Is your sense of smell impaired due to a covid-19 infection?
   Yes/No/By another disease

3. How stressful was your day until now?

|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|
Not at all Extremely

4. How would you rate your current mental wellbeing?
   a) Very poor
   b) Poor
   c) Average
   d) Good
   e) Very good

5. How connected do you feel to nature? Please choose the figure that represents your relation with nature the best.



2.4.3 Smellwalking: semi-structured interview and questionnaires

On each location, a semi-structured interview was held during a smellwalk along the transects. The participants were asked to elaborate his/her olfactory experience. The interview functions as the core of the phenomenological approach taken by the study and serves to explore the olfactory dimensions of participants' landscape experience. At each location, a questionnaire was used to assess the overall olfactory environmental quality of the cityscape and the momentary feeling of wellbeing.

2.4.3.1 Pilot interviews

Two pilots were held to ensure the smellwalk method yielded the desired data. The pilots provided two insights of utmost importance. First, the moment of interviewing. Initially, the interview would be held *after* the walking. At the start of each transect the participants were asked to focus on their olfactory experience for the entire transect, while there is complete silence – hence no conversation between the participant and the researcher – during the walk itself allowing the participant to focus on their olfaction solely (as done by soundscape walks by Korpilo, to be published). However, this yielded little to no results, since the participants found it very difficult to answer the questions about previously experienced smells or remember their previous fugitive thoughts. Instead, the participants could only answer based upon the current smells, which were very few to none, since smells can be very momentaneous. Hence, interviewing *during* the walking appeared more fruitful.

Second, it appeared that asking directly to the participants' emotions or feelings did not yield much data. When asked which emotions or feelings were experience because of the smell, they often answered that no emotions or feelings were evoked. However, when asking the participant their *judgement* of the smell ("what do you think of [that smell]?" / "How do you like [that smell]?"), followed by asking "*Why?*" either one or several times, the participants explained their feeling towards that smell more implicitly. It also appeared that asking "*Why?*" triggered the participant to name other associations s/he had with that smell. Therefore, the probing questions were adjusted accordingly.

2.4.3.2 Interview guide

The interviews aimed to answer RQ1, RQ2a (partly) and RQ2b. Interviews were held in Dutch. This section presents both the original question (NL) and the translation (EN). It was important that the interviewer did not steer the perception of the participant. Accordingly, the interviewer could not ask "*Which smells do you smell now?",* since this will determine the focus of the participant at the moment of asking. Therefore, the main questions were asked at the start of each transect, in the form of one large interview question:

> *NL: Ik zet zo de recorder aan. Kan jij vanaf dat moment beschrijven wat je ruikt, wat die geur met je doet, welke associaties het oproept en welke herinneringen het oproept?*

EN: I will turn on the recorder. Can you from that moment onwards start describing what you smell, which feelings this smell evokes in you, which associations it triggers and which memories it evokes?

The recorder was switched on and the transect was walked. The interviewer remained silent until the interviewee began talking about the smells s/he perceived. When participants stopped talking about the perceived smell, the interviewer began asking probing questions. The probing questions asked depended on the level of elaboration of the initial answering the main question. The following probing questions could be asked:

- Whenever a smell was mentioned briefly without going further into it:
    - *NL: [genoemde geur], kan je beschrijven wat voor geur dat is?*
    - *EN: [smell mentioned], can you describe what kind of smell that is?*

  Or:
    - *NL: Wat bedoel je met [genoemde geur]?*
    - *EN: What do you mean with [smell mentioned]?*
- Whenever the participant did not elaborate his/her perception of the described smell:
    - *NL: Wat vindt je van die geur?*
    - *EN: How do you like that smell? / What do you think about that smell?*
- Whenever the participant did not elaborate their judgement based upon feeling, associations or memories:
    - *NL: Waarom …….*
    - *EN: Why ……*
    - *…Followed by an summary of the participant previous answer. Per example: Why do you dislike the smell of cigarette smoke?*
- When the end of the transect was approached and the participant had been silent for at least 1.5 minutes, it was asked:
    - *NL: Heb je de afgelopen minuten nog iets anders geroken?*
    - *EN: Did you smell anything else the last couple of minutes?*

At the end of the third and last transect and after filling in the third questionnaire, the participant were asked two last questions. The first one to see whether an important notion was missed during the smellwalk, the second to examine the preference of smellscape explicitly to answer RQ2 and RQ2b.

- *NL: Wat vond je van de geurwandeling in het algemeen?*
- *EN: What did you think about the smellwalk in general?*

  and
- *NL: Stel je loopt de deur uit, welke geuromgeving zou je prefereren en waarom?*
- *EN: Imagine walking out of your house, which olfactory environment would you prefer and why?*

2.4.3.3 Scale questionnaires

At the end of each transect, the participants were asked to fill in a questionnaire to evaluate the overall olfactory environmental quality of the cityscapes in order to answer RQ2a and RQ2c. Participants were first asked to rank the visual and olfactory pleasantness on a 5-point scale (very unpleasant, unpleasant, neutral, pleasant, very pleasant), since pleasantness is a dominant dimension in the affective response to olfactory stimuli and landscape experience (see introduction; Yeshurun & Sobel, 2010; Nasar, 1989).

Then, semantic differential scaling was used to ask the participants to fill in a detailed assessment of the smellscape by rating the smellscape on nine olfactory environment quality scales, based upon the framework developed by Xiao (2016) and Xiao et al. (2018): annoying-calm, artificial-natural, dislike-like, mixed-pure, not as expected-as expected, stale-fresh, unclean-clean, unfamiliar-familiar and weak-strong. In the study by Xiao (2016), these characteristics were experienced by the participants as opposites. The left characteristics represent negative evaluation of smellscapes – except for weak-strong, were strong is said to be a negative experience of smellscapes (Xiao, 2016). The characteristics were set on a 1 to 10 scale, wherein 1 represents the most negative score (e.g. most annoying) and 10 the most positive score (e.g. most calm). Hence, there was no truly neutral option, however 5 and 6 can be considered as such. See the full questionnaire in box 2, and the original Dutch one in appendix II.

Lastly, the participants were asked to evaluate their momentary feeling of wellbeing on a six-point scale (rather the opposite, not at all, slightly, moderately, yes, very much so). See box 2 for the questionnaire and appendix II for the survey as presented to the participants.

2.5 Data analysis

The qualitative data obtained by the interviews was analysed with a study-specific coding system, consisting of different coding methods developed by Saldaña (2009), followed by a thematic analysis. This is explained in section 2.5.2. The scores from the questionnaires were taken together and statistically analysed on differences and possible correlations, described in section 2.5.1.

2.5.1 Questionnaire scores

The data from the questionnaires was used to: compare visual and olfactory pleasantness experienced by the participants, compare the different urban settings on perceived smellscape qualities, and the participants momentary feelings. The data from the questionnaires were taken all together, hence not analysed per participant.

Box 2. Scale questionnaire for the end of each transect, to assess the perceived olfactory environmental quality of the cityscape, based on Xiao et al. (2018), and participants' momentary feeling of wellbeing.

I. a. How pleasant is this visual environment to you?
(*very unpleasant/unpleasant/neutral/pleasant/very pleasant*)
b. How pleasant is this olfactory environment to you?
(*very unpleasant/unpleasant/neutral/pleasant/very pleasant*)

II. Rate the smellscape on the following scales:

Background										Strong
Mixed										Pure
Unclean										Clean
Stale										Fresh
Annoying										Calm
Dislike										Like
Unfamiliar										Familiar
Inappropriate										Appropriate
Artificial										Natural

III. Focussing on the olfactory environment, how do you feel at this moment?
Answers on scale: rather opposite/not at all/slightly/moderately/yes/very much
a. I feel calm
b. I feel relaxed
c. I feel energetic
d. I can forget the everyday here
e. My mind is clear here

2.5.1.1 Visual and olfactory pleasantness

The data on visual and olfactory pleasantness was translated into ordinal data: very unpleasant (-2), unpleasant (-1), neutral (0), pleasant (1) and very pleasant (2).

These scores were grouped per sense and per location. The **Friedman's test** for paired observations was used to see whether difference existed among the three locations. The Friedman test compares the difference in tendency between 3 or more paired observations, when data is ordinal and not normally distributed, and can be used for smaller samples. The observations in my study are paired, since the same individual rates three different environments. When significance was found, the **Wilcoxon Signed Rank test** was used for post-hoc analysis. The Wilcoxon Signed Rank test is suitable for paired observations, when data is ordinal and not normally distributed.

The correlation between visual and olfactory pleasantness over all locations was tested using **Spearman's rank correlation.** The correlation between self-perceived nature connectedness and pleasantness scores was also tested using Spearman's correlation.

2.5.1.2 Olfactory environmental qualities scales

The scores from the olfactory environmental quality scales were grouped per quality and location. For each quality, the difference in scores between the three locations was tested on significance. The **Friedman's test** for paired observations was used to see whether difference existed among the three locations. If so, the **Wilcoxon Signed Rank test** for paired observations was used post-hoc to analyse which difference between two locations caused the significance difference.

The scores of each of the nine scales were also tested on correlation with the olfactory pleasantness score, using **Spearman's rank correlation**. The correlation between self-perceived nature connectedness and olfactory quality scores was also tested using Spearman's correlation.

2.5.1.3 Momentary wellbeing

Answers on the self-perceived momentary wellbeing questions were translated into ordinal data: rather the opposite (-1), no (0), slightly (1), moderately (2), yes (3), very much so (4). The scores were grouped per question and location. For each question, the difference in scores between the three locations was tested on significance. The **Friedman's test** for paired observations was used to see whether difference existed among the three locations. If so, the **Wilcoxon Signed Rank test** for paired observations was used post-hoc to analyse which difference between two locations caused the significance difference.

The scores of each of the five questions were also tested on correlation with the olfactory pleasantness score and the visual pleasantness score using **Spearman's rank correlation**.

2.5.1.4 Personal Data

Data was analysed in relation to personal information to test whether personal characteristics influenced the scores given. The score on the Nature Connected scale (NC) was tested on correlation using **Spearman's rank correlation,** with both visual and olfactory pleasantness scores (per sense per location, a total of 6 tests) and the scores of the olfactory environmental quality scales (per criterium per location, a total of 27 tests).

Participant data was divided into 1) smokers and non-smokers, and 2) no impaired and impaired sense of smell. Difference among the two groups on pleasantness scores and olfactory environment qualities scores was tested on significance using the **Mann-Whitney U test** for independent samples (a total of 2 x 33 tests, of which 6 for pleasantness and 27 for scales).

Participant data was divided in several education levels. Substantial groups that had more than one member (MBO, HBO, BSc, MSc) were further analysed. Difference among two groups on pleasantness scores and olfactory environment qualities scores was tested on significance using the **Mann-Whitney U test** for independent samples (a total of 6 x 33 tests, of which 6 for pleasantness and 27 for scales).

Several assumption were made for this data analysis. If the Nature Connectedness score (NC) did correlate with just one score on one location, this was considered a coincidental correlation. Thus, is was assumed that: ***if*** *NC correlated with any score on any location,* ***then*** *NC also correlates with that score on at least one other location,* ***or*** *NC also correlates with at least another score on the same location* ***Else*** *the singular correlation found is coincidental*. Similarly, if two groups (from either smoking, sense of smell or education level) had significantly different scores of just one score on one location, this was considered a coincidental correlation. Thus, it was assumed that: ***if*** *two groups score a criterium on a location significantly different,* ***then*** *the same groups also score at least one other criterium on the same location,* ***or*** *the same criterium on at least one other location also significantly different.* ***Else*** *the singular correlation found is coincidental.*

2.5.2 Interview data: thematic analysis and coding

The qualitative interview data was analysed using thematic analysis, which requires coding the text. Thematic analysis 'is a method for systematically identifying, organizing, and offering insight into patterns of meaning (themes) across a data set' (Braun & Clarke, 2012, p.57). Hence, thematic analysis is to make sense of commonalities within experiences and overarching meanings in a data set (Braun & Clarke, 2012). Thematic analysis can also include: comparing the frequencies of occurring codes, analysis co-occurrence of codes and graphical displaying of relationships between codes (Guest et al., 2012).

Before themes can be generated, the data is systematically analysed through coding (Braun & Clarke, 2012). The purpose of coding is to label units of raw data that are potentially relevant for answering the research questions.

The interview recordings were transcribed manually by listening to the recording and typing the spoken words in a txt-file. This resulted in 125 pages of text, with which I familiarised myself by scanning and reading it in order to come up with a coding system.

I developed a study-specific coding system based on different coding methods described by Saldaña (2006). The first important step was to reduce the text to relevant

Table 1. An example of the coding process, translated from Dutch. Three information units (72f, 227a, 369b) are assigned a process code *and a* in vivo *or* summarised code *in the first cycle of coding (see appendix III for full explanation. In the second cycle of coding, they are assigned a* 2nd layer code *and* third layer code.

participants	number	letter	process code	in vivo OR summarised code	in vivo?	2nd layer code	3rd layer code
P_M4	72	f	describing	smell of soil	YES	(moist) soil	smells of nature
P_U3	227	a	judging	does smell nice	YES	nice	POS
P_W4	369	b	noticing	suddenly something very strong	YES	locality smells	locality smells

information units, which is shown through an example in figure 1a-b. A total of 421 distinct olfactory observations made by participants was found in the texts, 157 in GREY, 134 in SEMI and 130 in GREEN. The text was reduced to 1918 information units. Each information unit was labelled with several layers of codes. Each layer of coding merged the information units in broader categories without losing valuable information. The coding process is detailly explained step-by-step in appendix III. An example is shown in table 1.

After coding, themes were generated by analysing and connecting (categories of) codes. The thematic analysis remained as close to the data as possible, hence, with as little interpretation as possible. Each theme combines different categories of codes and hovers above the data, so to say. In the themes, I also referred to the questionnaire scores to substantiate the themes were possible.

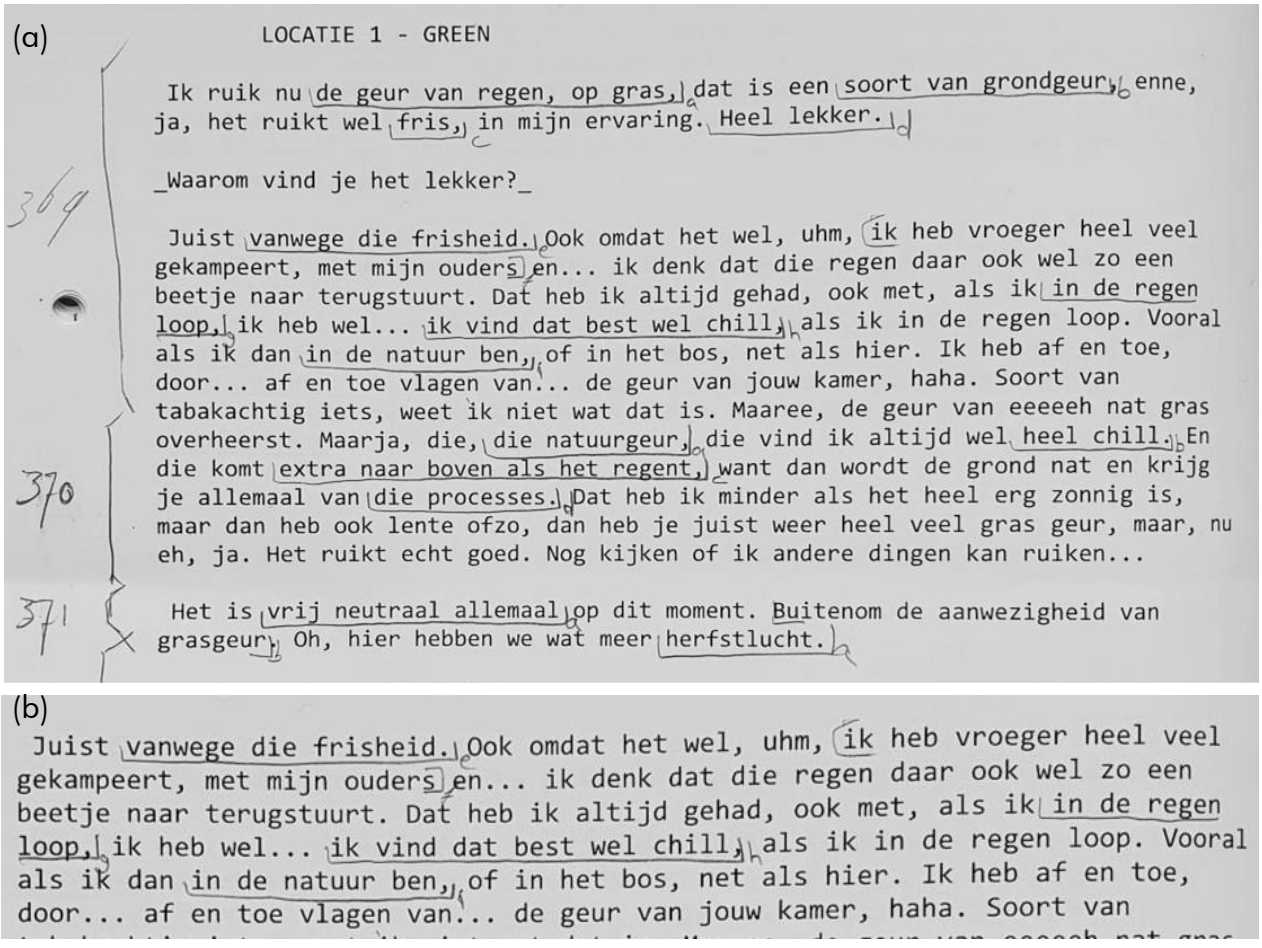


Figure 1. A small part of the interview transcript of P_W4 to illustrate how the transcript is reduced to information units. (a) Each olfactory observation is labelled a number, here olfactory observation 369-371 are visible, and (b) each information unit within an olfactory observation is labelled a letter, here e-i are visible.

3 Results: Olfactory Environmental Qualities

This chapter presents the questionnaire scores and the statistical analysis of the questionnaire scores. The data presented in this chapter will give insight in the perceived olfactory environmental quality and help to answer RQ2b: *what influences does urban nature have on the evaluation of the urban smellscape?*

3.1 Pleasantness scores

The scores of visual and olfactory pleasantness of the three locations were tested on differences. Figure 2 shows the distribution of pleasantness scores for both senses. Visual pleasantness was generally rated '*neutral*' and '*pleasant*' in GY, '*pleasant*' in SM, and '*pleasant*' and '*very pleasant*' in GN. Olfactory pleasantness was generally rated '*unpleasant*' and '*neutral´* in GY, '*neutral*' and '*pleasant*' in SM, and '*pleasant*' and '*very pleasant*' in GN. The statistical analysis of the pleasantness scores in shown in table 2 (p.33). For both visual and olfactory pleasantness, SM scored significantly higher than GY, and GN significantly higher than SM. Following the Spearman Rank correlation test, visual and olfactory pleasantness have a moderately positive correlation.

Figure 2. The distribution of pleasantness scores for both visual pleasantness and olfactory pleasantness per location, as rated by the participants at the end of each transect. The means are indicated with a cross. A score of (0) represents 'neutral', (-1) and (-2) represent unpleasant and very unpleasant respectively, (1) and (2) represent pleasant and very pleasant respectively.

3.2 Olfactory environmental qualities

Nine olfactory environmental qualities were rated on each location. Figure 3a-i (p.32) show the distribution of scores per olfactory quality and per location. Scores were tested on difference using the Friedman test for paired observation and the Wilcoxon Signed Rank test for post-hoc analysis. Table 3 (p.33) shows the statistical analysis of the olfactory environmental quality scores.

A significant difference in scores at all three locations was found for the scales annoying-calm, artificial-natural, musty-fresh and unclean-clean – in all cases SM higher than GY, and GN higher than SM. These scales were also found to have a moderately positive correlation with olfactory pleasantness scores following the Spearman Rank correlation test.

On the scales dislike-like, mixed-pure and weak-strong only GN scored significantly higher than SM and GY. These scores had either a moderately or weakly positive correlation with olfactory pleasantness scores.

No significant difference was found for the scales unfamiliar-familiar and not as expected-expected. No correlation between these scores and olfactory pleasantness scores was found.

3.3 Personal Data

The score on the Nature Connectedness scale was tested on correlation with each sense on each location (a total of six tests) and with each score on each location (a total of 27 tests) using the spearman's rank correlation. Only one correlation was found: the score on the weak-strong scale in GN ($r_{(25)}$=-.41, p.043). According to the assumption made in section 2.5.1.4, this single correlation is considered a coincidence.

Also when comparing the groups of education level and smokers, score differences were only found exceptionally, for instance a difference between education level 2 and 4 on one score on one location. According to the assumption made in section 2.5.1.4, these exceptions are considered coincidental.

Figure 3. The distribution of scores for each olfactory quality scale per location, based on the framework developed by Xiao et al. (2018). The scores were given by the participant to rate the overall olfactory quality of the environment at the end of each transect. The means are indicated with a cross.

Table 2. Results from the statistical analysis of questionnaire data on visual and olfactory pleasantness. A non-parametric Friedman test was conducted to see whether there was a different tendency in scores among the three locations. If the test rendered a significant Chi-square value, Wilcoxon Signed rank tests were conducted to see which locations' scores differed significantly. The correlation with olfactory pleasantness score was tested using a Spearman's rank test. diff.? = indication whether scores were significantly different between locations; relation? = indication of relation between quality scale and olfactory pleasantness, with 0.2-0.4 considered as a weak, 0.4-0.8 as a moderate and 0.8-1.0 as a strong relation.

sensory pleasantness	non-parametric Friedman test			post-hoc Wilcoxon Signed Rank test						Correlation with olfactory pleasantness score tested with Spearman's rank test		
				difference grey-semi			difference semi-green					
	Chi-square	p-value	diff.?	Z-value	p-value	diff.?	Z-value	p-value	diff.?	r coefficient	p-value	relation?
visual	32.00	<.001	yes	-3.12	.002	yes	-3.12	.002	yes	$r_{(373)} = 0.64$	<.001	moderately positive
olfactory	29.76	<.001	yes	-2.55	.011	yes	-3.17	.002	yes	-	-	-

Table 3. Results from the statistical analysis of questionnaire data on the olfactory environment quality scales. A non-parametric Friedman test was conducted to see whether there was a different tendency in scores among the three locations. If the test rendered a significant Chi-square value, Wilcoxon Signed rank tests were conducted to see which locations' scores differed significantly. The correlation with olfactory pleasantness score was tested using a Spearman's rank test. diff.? = indication whether scores were significantly different between locations; relation? = indication of relation between quality scale and olfactory pleasantness, with 0.2-0.4 considered as a weak, 0.4-0.8 as a moderate and 0.8-1.0 as a strong relation.

olfactory environmental quality scale	non-parametric Friedman test			post-hoc Wilcoxon Signed Rank test						Correlation with olfactory pleasantness score tested with Spearman's rank test		
				difference grey-semi			difference semi-green					
	Chi-square	p-value	diff.?	Z-value	p-value	diff.?	Z-value	p-value	diff.?	r coefficient	p-value	relation?
annoying-calm	26.99	<.001	yes	-2.44	.015	yes	-3.21	.001	yes	$r_{(73)} = 0.58$	<.001	moderately positive
artificial-natural	33.38	<.001	yes	-2.47	.014	yes	-3.60	<.001	yes	$r_{(73)} = 0.66$	<.001	moderately positive
dislike-like	26.29	<.001	yes	-1.59	.111	no	-3.56	<.001	yes	$r_{(73)} = 0.72$	<.001	moderately positive
mixed-pure	26.57	<.001	yes	-1.44	.149	no	-3.14	.002	yes	$r_{(73)} = 0.62$	<.001	moderately positive
not as-as expected	4.33	.115	no	-	-	-	-	-	-	$r_{(73)} = 0.18$	.112	no
musty-fresh	18.15	<.001	yes	-2.09	.037	yes	-2.91	.004	yes	$r_{(73)} = 0.47$	<.001	moderately positive
unclean-clean	26.60	<.001	yes	-3.18	.001	yes	-3.33	.001	yes	$r_{(73)} = 0.63$	<.001	moderately positive
unfamiliar-familiar	4.35	.114	no	-	-	-	-	-	-	$r_{(73)} = 0.17$	.155	no
weak-strong	7.80	.020	yes	-.175	.861	no	-3.11	.002	yes	$r_{(73)} = 0.29$	.012	weakly positive

4 Results: Self-Perceived Wellbeing Scores

Five questions on self-perceived momentary wellbeing were answered at the end of each transect. Figure 4a-e shows the answers on each question per location. In general, answers were more positive in SM than in GY, and more positive in GN than in SM - shifting from *'no', 'slightly'* and *'moderately',* to *'moderately', 'yes'* and *'very much so'* (fig. 4a-e).

Answers were tested on difference using the Friedman test for paired observations and the Wilcoxon Signed Rank test for post-hoc analysis. The results from the statistical analysis are shown in table 4. With one exceptions (*I feel energetic,* difference GY and SM), all questions were answered significantly more positive in GN than in SM, and in SM than in GY. For every question, the scores correlate either weakly or moderately with both olfactory and visual pleasantness, following the Spearman Rank correlation test (table 4).

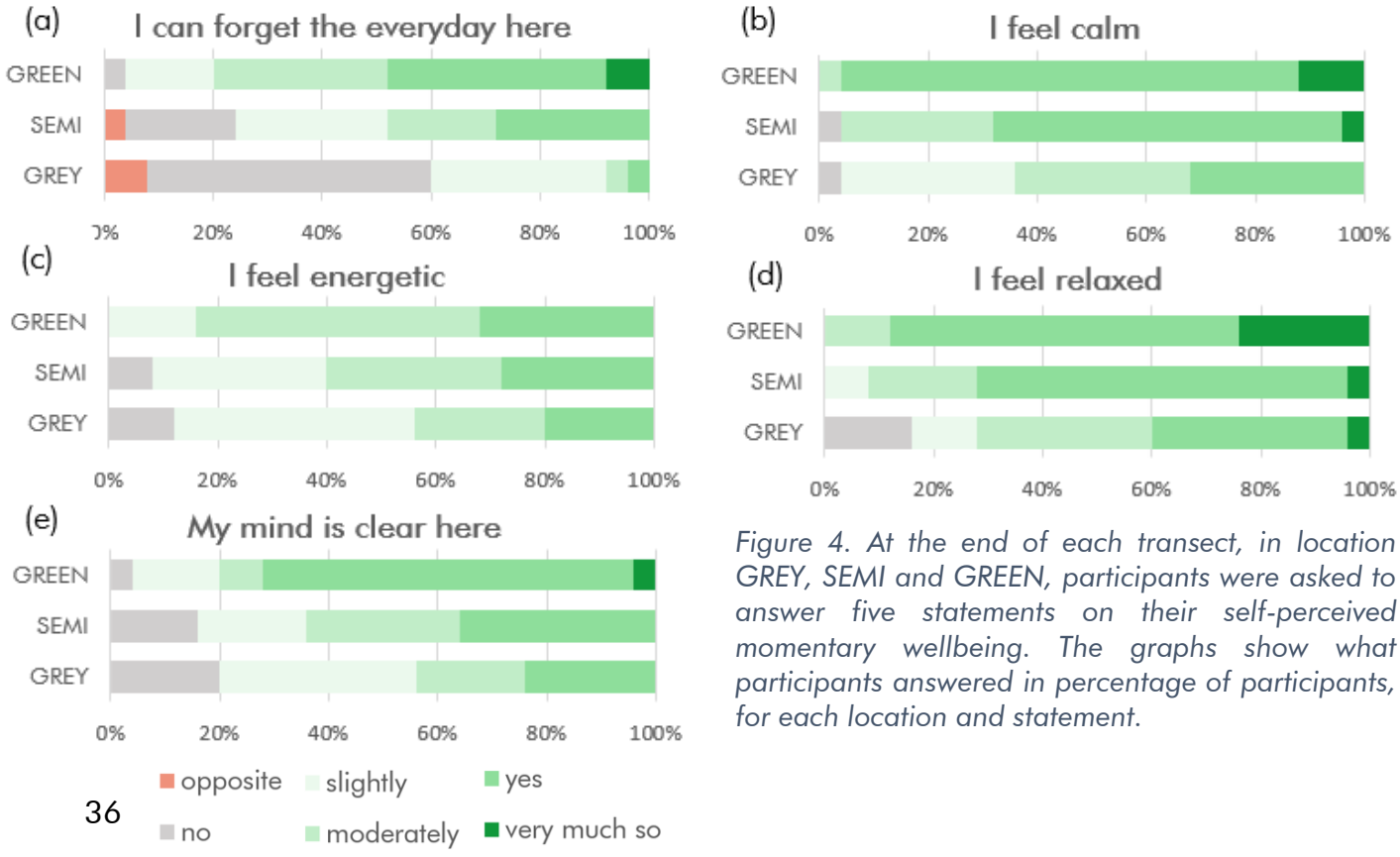


Figure 4. At the end of each transect, in location GREY, SEMI and GREEN, participants were asked to answer five statements on their self-perceived momentary wellbeing. The graphs show what participants answered in percentage of participants, for each location and statement.

Table 4. Results from the statistical analysis of questionnaire data on self-perceived momentary wellbeing. A non-parametric Friedman test was conducted to see whether there was a different tendency in scores among the three locations. If the test rendered a significant Chi-square value, Wilcoxon Signed rank tests were conducted to see which locations' scores differed significantly. The correlation with olfactory and visual pleasantness score was tested using a Spearman's rank test. diff.? = indication whether scores were significantly different between locations; relation? = indication of relation between quality scale and olfactory pleasantness, with 0.2-0.4 considered as a weak, 0.4-0.8 as a moderate and 0.8-1.0 as a strong relation.

questionnaire statement	non-parametric Friedman test			post-hoc Wilcoxon Signed Rank test						Correlation with olfactory pleasantness (o) and visual pleasantness (v) score tested with Spearman's rank test		
				difference grey-semi			difference semi-green					
	Chi-square	p-value	diff.?	Z-value	p-value	diff.?	Z-value	p-value	diff.?	r coefficient	p-value	relation?
I can forget the everyday here	33.37	<.001	yes	-3.57	<.001	yes	-2.91	.004	yes	o: $r_{(73)}$= 0.54 v: $r_{(73)}$= 0.65	<.001 <.001	moderately positive moderately positive
I feel calm	21.28	<.001	yes	-2.50	.013	yes	-2.21	.027	yes	o: $r_{(73)}$= 0.65 v: $r_{(73)}$= 0.54	<.001 <.001	moderately positive moderately positive
I feel energetic	14.00	.001	yes	-1.84	.066	no	-2.25	.024	yes	o: $r_{(73)}$= 0.24 v: $r_{(73)}$= 0.27	.036 .021	weakly positive weakly positive
I feel relaxed	12.19	.002	yes	-2.43	.015	yes	-2.04	.041	yes	o: $r_{(73)}$= 0.56 v: $r_{(73)}$= 0.48	<.001 <.001	moderately positive moderately positive
my minder is clear here	8.33	.016	yes	-2.11	.035	yes	-2.22	.026	yes	o: $r_{(73)}$= 0.50 v: $r_{(73)}$= 0.47	<.001 <.001	moderately positive moderately positive

5 Results: Describing and Judging Smells

In the coding process, information units containing a description or judgement of a perceived smell were coded as such – among various other categories (see appendix III). This chapter presents the main categories of described smells in each location as well as patterns of judgements related to perceived smell sources. It is by no means a complete overview of all codes (in detail), but shows a general tendency in the data. Appendix IV shows the full set third layer codes.

The perceived smells are the observations that triggered the olfactory landscape experiences. Therefore, it is key to know which smells were perceived to make sense of the thematic analysis. It is also an important part for answering RQ1a and RQ2a: *which olfactory elements does urban nature bring into the perceived urban smellscape?;* and *which elements of the urban smellscape are perceived as pleasant?*

According the theory described in the introduction, the affective response to landscape elements form the fundament of landscape experience. Pleasantness especially is considered a key dimension in both landscape preference and olfactory perception (section 1.2 and 1.3). The judgements represent the affective responses as expressed by participants and form the step towards describing olfactory experiences in terms of associations, feelings and memories. Therefore, knowing the initial judgement of smells helps to understand the thematic analysis.

5.1 Describing: perceived sources of smell

In this section, the described smells will be discussed on the level of 2nd and 3rd layer codes (see appendix III). 575/1918 information units were descriptions, hence on average each olfactory observation had (575/421=) 1.37 describing codes.

5.1.1 Smell sources per location

This section provides an overview of the largest categories of perceived smells per location. Table 5 shows the smell sources in GY, table 6 shows the smell sources in SM and table 7 shows the smell sources in GN. Table 5-7 do not show all subcategory of the main categories, only the main ones.

Table 5. The main categories and subcategories of perceived smells along the transects in locations GREY.

Smells from human objects	59	Food smells	18
		Building material	9
		cars (not gasses)	7
		chemicals	6
		perfume/deo	5
		frying fat	5
		soap	5
absence of smell	31	no smell	15
		neutral smell	8
		not much	7
city smells	30	musty background smell	14
		city smell	7
		street stones	6
		buildings	4
		'no nature'	5
gasses and smoke	26	exhaust gasses	13
		fire place	7
		cigarette smoke	6
smell of air	17	cold/fresh air	9
		bad smell	4
smells of nature	14	(moist) soil	5
		plants	5
smell of waste	11	-	
undefinable smell	5	-	
mixed pallet	4	-	

Table 6. The main categories and subcategories of perceived smells along the transects in locations SEMI.

Smells of nature	87	decomposing leaves	22
		water	12
		plants	6
		(moist) soil	5
		autumn smell	5
		forest smell	4
		mosses	4
Smells from human objects	26	cars (not gasses)	11
		food smells	3
		chemicals	3
absence of smell	22	not much	11
		absence of smell	6
		neutral smell	5
gasses and smoke	14	exhaust gasses	6
		fire place	6
smell of air	14	cold/fresh air	8
		moist air	4
city smells	8	must background smell	3
		canal water	2
mixed pallet	6	-	
animal smells	5	-	
smell of waste	4	-	

Table 7. The main categories and subcategories of perceived smells along the transects in locations GREEN.

Smells of nature	125	decomposing leaves	26
		plants/green leaves	20
		(moist) soil	16
		flowers	8
		(moist) grass	7
		water	5
		autumn smell	4
		forest smell	4
		pines	4
Smell of air	14	cold/fresh air	9
		moist air	4
Smells from human objects	12	perfume/deo	4
		sweetness	3
animal smells	8	dog faeces	8
absence of smell	6	-	
undefinable	5	-	
city smell	4	-	

5.1.2 Smells of nature

Smells of nature is an important category for answering research question 1a. The category has a total of 226 describing codes (around half of the total describing codes), of which 14 in GY, 87 in SM and 125 in GN. The smells that were mentioned at least twice are listed in table 8.

Table 8. Perceived smells of nature mentioned at least twice, counted in total and per location.

Perceived smell	All	GY	SM	GN
Decomposing Leaves	49	1	22	26
Plants / green leaves*	34	5	8	21
(Moist) soil	26	5	5	16
Water	17	0	12	5
(Moist) grass	13	0	6	7
Autumn smell**	11	-	5	6
Flowers	10	1	1	8
Forest smell(**)	8	-	4	4
Rain	6	1	3	2
Fermenting smell	5	-	2	3
Pine trees	4	-	-	4
Mosses	4	-	4	-
Brackish water	3	-	3	-
Chestnuts	3	-	-	3
Animals	2	-	2	-
Raspberry	2	-	2	-
Mushrooms	2	-	-	2
Ferns	2	-	-	2

**Including* plants / green leaves, moist plants *and* plants (or separate shrubs, or separate trees). *Thus, three different 2nd layer codes.*
**Refers (mainly) to the same source as *decomposing leaves,* only named differently

Decomposing leaves (and "*autumn smell*") is most frequently smelled, with almost equal frequencies in SM and GN. Second most often smelled is *plants / green leaves*, especially in the urban park (GN) – in the interviews, some individual plants were named, such as Hedera helix, Taxus and Common Snowberry. In GY and SM, this category occurred in the form of individual plants, shrubs and trees. Third most often smelled is (moist) soil, also referred to as "earth", mostly in GN. Fourth most often smelled is water, mostly the water body in SM.

Grass was smelled in both SM and GN almost equally and despite the autumn, some *flowers* were still smelled, especially in GN. Sometimes, a smell source in SM or GN was described as *forest smell,* but the forest occurred more often as an association (see 6.2.2).

Other then that, smells were very location or time specific. For instance, *brackish water* was mentioned several times at a specific spot in SM where water was motionless; and a *raspberry* plant was present somewhere along the SM transect. *Rain* was time specifically mentioned after a rainy day.

5.2 Judging: evaluation of smells

Smells were mainly judged by participants in terms of pleasantness. Judgement of smells were coded with a degree of being positive or negative in the third layer of coding (see appendix III). There was a total of 404 judging codes, hence, on average an observation unit had (404/421=) 0.96 judging codes. However, an olfactory observation could also include two or more judging codes, indicating that not every olfactory observation was interpreted with a judgement. Hence, this section is not a complete overview of the perceived smells, but rather an indication of the general tendency in de data.

The analysis here shows 3rd layer codes, being five categories – very negative, negative, neutral, positive and very positive – because second layer codes came in sixty different formulations. Dominant formulation on the 2nd layer of coding were: *good* and *not good* (45, 26), *pleasant* and *unpleasant* (34, 24), *neutral* (32), (comfortably) *nice* and *not nice* (23, 23), *fresh (as in pleasantly)* (22) and superlative degrees of that.

Figure 5a-c shows a full overview of the amount of judgements per source of smell. *When one* olfactory observation had two or more judgements referring to the same smell, this was still displayed as one judgement in the graphs to prevent misleading numbers. The most explicit or strong evaluation was chosen.

The graphs shows a shift in judgements from GY to SM to GN: less (very) negative judgements and more (very) positive judgements of smell sources. Both because GY has more sources emitting negatively judged smells that were not or less present in SM and GN, and because SM and especially GN had sources emitting positively judged smells that were (largely) absent from GY.

The figure shows that GY has the most negative and very negative judgements, the most neutral judgements, and the least positive and very positive judgements. The largest categories that were judged (very) negatively are *waste, cigarette smoke, exhaust gasses* and *must city smell*. Large categories of smells in GY judged (very) positively are mostly *food smells*, *plants, fire places* and *fresh air*. See figure 5a for a full overview.

In SM, there are less (very) negative and neutral judgements than in GY and more (very) positively judgements. *Exhaust gasses* remains a prominent category of negatively judged smells. *Decomposing leaves, fresh air* and *plants* are large categories of positively judged smells. See figure 5b for a full overview. GN has the least (very) negatively judged smells, with only *dog faeces* as a notable category, and a similar amount of neutral judgements as SM. GN has a the largest amount of (very) positive judgements, coming mostly from *decomposing leaves, (moist) soil, plants* and other nature related smell sources. See figure 5c for a full overview.

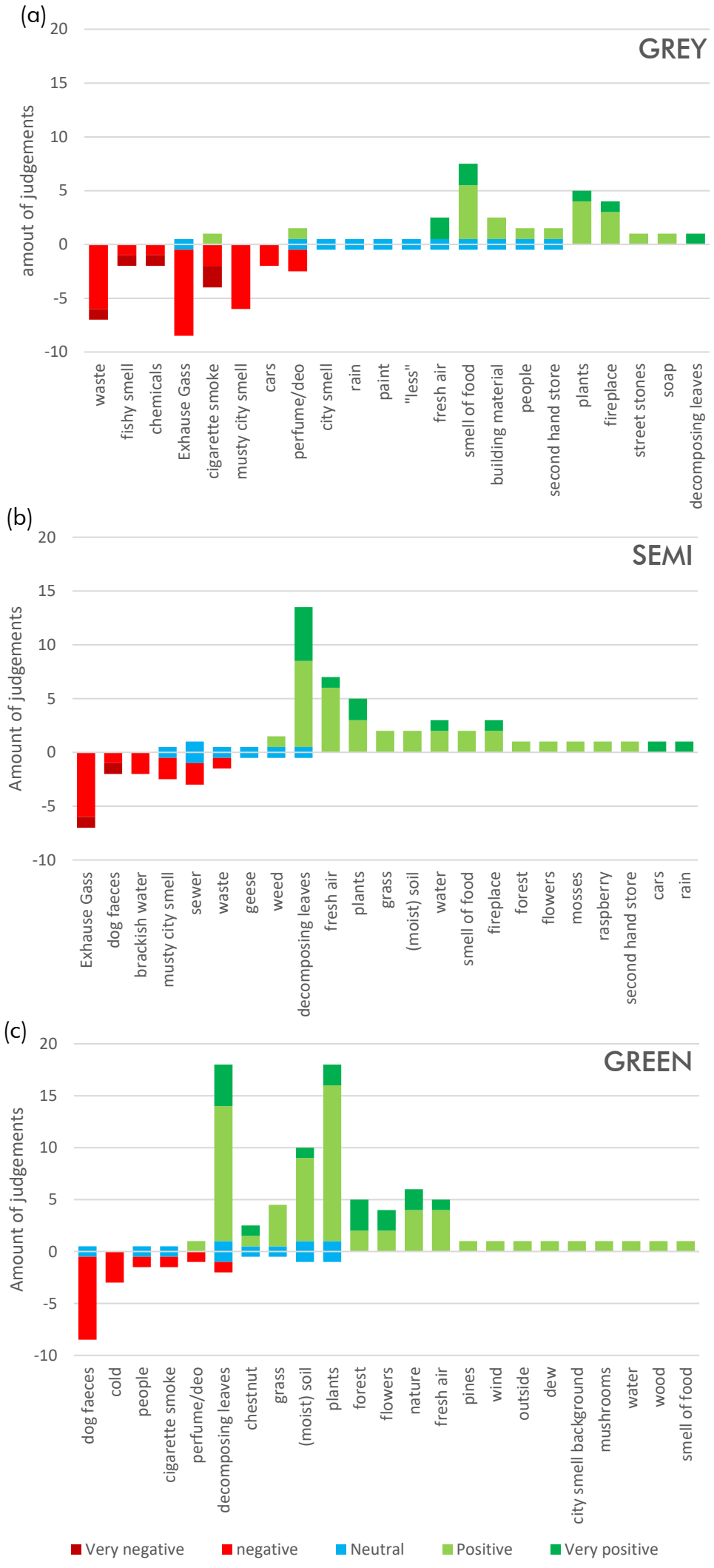


Figure 5. Count of categories of judgement codes occurring at each location. Judgement codes were divided into five categories: very negative, negative, neutral, positive and very positive. The graphs show these categories per perceived smell category. When one olfactory observation had two or more judgements referring to the same smell, this was still displayed as one judgement in the graphs to prevent misleading numbers. The most explicit or strong evaluation was chosen. The graph shows a general tendency in the data, but it by no means a complete overview of the interview data.

6 Results: Thematic Analysis

This chapter presents the results from the thematic analysis. The perceived smells and judgements of smells on which the themes are based are presented in chapter 5. The themes combine the smell sources and judgements with associations and experiences, elaborating participants' olfactory landscape experience. Besides, the questionnaire data is used to substantiate the themes where possible to increase the themes' validity.

Every section in this chapter presents a theme. Section 6.1 describes the perceived smellscapes in a thematic way, which aims to answer RQ1a: which olfactory elements does urban nature bring into the perceived urban smellscape? Section 6.2 describes two dominant themes that are considered most important for the study, and three smaller themes that also provide insight in smellscape experience. These themes are relevant in answering RQ1b, RQ1c and RQ2a: *what influences does urban nature have on the interpretation of the perceived urban smellscape through associations?; what influences does urban nature have on the feelings evoked by the urban smellscape?*; and *which elements of the urban smellscape are perceived as pleasant?* – and provide insight in possible answers to RQ3: *to what extend does the olfactory experience of urban nature contribute to a landscape that fosters wellbeing?* Section 6.3 describes the smellscape preference of participants in a thematic way, aiming to answer RQ2. Lastly, section 6.4 discusses a few notions of reflection expressed by participants', which form a bridge to the discussion in section 7.2.

6.1 Perceived smellscapes

This section describes the perceived smellscapes at each location (GY, SM and GN) in a thematic way. It serves to answer RQ1a.

6.1.1 GREY: a neutral or musty background with contrasting strong whiffs

In general, the smellscape of GREY was perceived as rather weak smelling over the entire transect. *'Yes, and it does not change,'* said P_U5. Participants often noticed the absence of smells and the continuity of this absence. It could happen that, aside from

the observation of smell absence, participants said almost nothing during the entire transect. The absence of smell was often perceived as neutral, therefore also not triggering explicit feelings or associations.

After a while, around half of the participants did notice a certain background smell that was perceived as musty or dirty. In the words of P_U2: '*Smell here has a certain undertone.*' As P_W4 formulated it after noticing the musty smell once: '*No, I have to say, now I have got hold of a continuous presence of a kind of musty sewer smell.*' It was mostly described as a *musty* or *fishy smell,* also shown by the high scores in being musty (section 3.2). Despite this smell being judged negatively, participants moderated their negative judgement because they were used to it or because *it is a normal part of the city,* which is also shown by the scores on expectedness and familiarity, both being rather high (section 3.2).

Some participants mentioned the experience of fresh air. For instance, P_M6 began the transect saying: '*I only smell the fresh air sometimes. […] I think the fresh morning air smells really nice, it really wakes you up.*' Participants were not always sure whether fresh air was an olfactory perception or only a taken breath. Fresh air could be experienced close to a spot where the musty or dirty city smell appeared, indicating that the two perceptions were not mutually exclusive.

On this rather empty olfactory canvas, strong whiffs appeared quite often. Especially exhaust gasses and cigarette smoke were often present. P_U1 explained it clearly: *'…the city is rather odourless. Except indeed a motor scooter or a vehicle.'* These whiffs were perceived very local in space and evaporative – except when walking in the direction of the smell's dispersion. The contrast between the weak background and the strong whiffs is shown in the scores on the weak-strong scale, being anywhere from 2 to 9 on 1 to 10 (section 3.2), and in the scores high in being mixed (section 3.2).

Often, these whiffs were framed negatively, especially cigarettes, exhaust gasses or waste containers, and were said to be penetrating. For instance, P_M10 said about a cigarette: '*Really disgusting I think. […] and without knowing it, you suddenly get such a smother…'*. P_M1 experienced '*nasty […] suddenly a very fat air through your nose.*' P_U6 expressed it strongest of all: '*It takes over, it is in one punch PAM, an artificial smell in your nose.*' Those negatively perceived penetrating smells not rarely evoked negative feelings or associations with dirtiness or being unhealthy. The relatively high occurrence of negatively perceived whiffs of smell is also shown by the score relatively high in annoyance (section 3.2).

Smells of nature, smelled when just a single tree was present, were also directly and strongly noticed, but framed positively. As P_M9 explained: '*I have to say that on this point, where immediately we also see four trees, you notice that the smell of nature comes to the foreground.*' Or as P_M6 said it when smelling a single plant after having walked behind a smoking pedestrian: '*Now I smell again some more… plants […] Healthy, as it is supposed to be.*' Also the smell of food was perceived positively, reminding participants the cosy life of people and triggering their own hunger.

After these smells were observed and faded, the olfactory perception returned to the absence of smell, neutral smell or musty smell. The dominance of either absence or naturalness is also shown by the questionnaire scores, as all olfactory quality scales were rated around 5 and 6 on a 1 to 10 scale (section 3.2).

6.1.2 SEMI: a mixed smellscape with freshness, nature and cars

The smellscape of SEMI was characterised by a highly mixed pallet, noticed as such by approximately all participant. Mainly caused by different sources of strong smell existing close to each other: cars, nature, water bodies and houses. Notwithstanding, it could occur that participant did not smell much on a certain part of the transect, but these observations were formulated different than in GY: whereas in GY the *absence* and *neutrality* was pointed out; in SM it was either *nothing much* or *weak,* indicating a slight presence of something rather than nothing, or *'just many things but nothing in particular'* (P_W7).

Despite being a landscape dominated by buildings and pavement, the musty city smell from GY was not mentioned in SM (except at certain parts in Utrecht, but this will be explained in the last paragraph of this section). Some participants, such as P_M11 did explicitly state that *'the mustiness that we just had in those little streets [GY], that is, is totally gone here.'* According to P_M6 this was because *'the houses are more musty'* than the moist and fresh air in SM.

Freshness was frequently perceived. Participants experienced freshness due to grass, trees, water or the openness of the area. Freshness was referred to as an association, an experience of breath and especially as a judgemental argument for pleasantness. P_M3 experience that *'It refreshes my mind,'* and P_M5 said to have *'A fresh feeling'*. Again, participants sometimes could not tell whether it was a olfactory or breathing experience, as for instance P_U1 said that *'it rather feels fresh, it is not per se that I can really smell it. […] it just feels like […] you really get refreshed for a moment.'* Other participants explicitly referred to a fresh smell. For example, P_M8 said: *'You can smell the grass a bit. Actually still smells quite fresh,'* and P_W3 said: *'It smells like a fresh evening.'* P_W7 said to experience *'a relief'* – an literal translation from Dutch would be: *a re-breathing* – because of the *'clean cooled air'* he could *'take in'*. The notion of freshness was highlighted more frequently than in GY, also shown in section 3.2, where SM scored higher on freshness than GY.

More so then freshness, smells of nature dominated the olfactory perception of the participants most of the time. Section 3.2 also shows a significant higher score on naturalness compared to GY. Smells from trees, leaves, grass and/or water were noticed by almost all participants. The intensity of these smells did vary greatly in space. Along some parts of the transect, these smells were almost absent and taken over by the smell of either human objects or exhaust gasses. Whereas along other parts of the transect, the smells could be strong enough for participant to label it *forest smell* or associate it with being in nature or away from the city. P_M2 for instance, noticed that *'sometimes the smell of forest is more intense than on other spots. Maybe*

because we walk close to a tree,' and P_U5 noticed that *'yes, now you smell it much stronger again indeed.'* When smells of nature increased, the positive feelings and associations mentioned increased with it, such as *'beautiful element of nature'* (P_M8), *'a nostalgist feeling every time of walking with my parents through the forest'* (P_U6) and *'a comfortable feeling'* (P_W3).

The perception of freshness and nature could be disrupted by the presence of cars, which was noticed by almost all participants and took over the smellscape not rarely. P_W8 started the transect saying: *'What is this smell? I associate it a bit with the cars around me that did something. Bit musty […] not very pleasant […] Not a fresh smell. […] Like a car just started up.'* While later on the transect, the smells of the grass and the trees took over his perception. Similarly, P_M6 said: *'And here you smell the trees, shrubs, fresh air. Except now, now we are approaching the spot where all the cars are, and now you suddenly smell that engine, that engine smell.'* It should be noted that despite cars played an important role in SM, it was not as much mentioned as in GY.

Despite the overall sudden dominance of the cars, the judgement of the car smell could vary, a few participants liked the smell of cars, due to positive associations or memories. For example, P_W4 said: *'…that it makes me remember times that I myself was tinkering with a car,'* and P_M9 said: *'It makes me think of childhood, nicely going on vacation with a rental car.'* Others, and also the majority, disliked, if not say hated, the smell, due to the association with long diseases and pollution. P_W1 for instance, said: *'that does not evoke positive memories or associations… I get the feeling that my lungs are dying,'* and P_M2: *'uhm, yes, after all I do associate it with bad… Bad. Bad for the environment, bad for my health, when I breath it, when I coincidently take a deep breath, that I then breath in those gasses.'*

Similar reaction were evoked by garbage or waste containers, yet these smells occurred less often. The mix of nature, cars and garbage is also shown in section 3.2, where SEMI scores similar to GY on being mixed, and section 3.2, where SM scores similar to GY on being liked. Although the latter is contradicted by both pleasantness scores and the majority of the qualitative data.

The mixed character as well as the locality of smells was best illustrated by the transect in Utrecht. In Utrecht, the transect went along a typical Dutch city canal, which lay 4 meter below main street level (see fig. 6). To have a transect of around 5 minutes, participants had to go up, cross the main street and go down again once.

Figure 6. The SEMI location in Utrecht. Participants walked along the canal, which is "downstrairs". To continue the transect, participants had to cross the road once at the level of the cars visible in the picture.

While being upstairs, the participants noticed a very clear change in smell, and going downstairs they often highlighted the change again. P_U1 said: '*I actually think, now I walk here, upstairs, now I think it smells different here from downstairs […] For me, downstairs […] smelled more free. Now the air is more pressing.*' And walking down P_U1 said: '*Yes, it smells really different here, from being up going down now, yes also because there are trees here, but it indeed just smells like forest, a bit those leaves. Yes, like a forest smell.*' P_U3 described the smellscape upstairs as its '*…smells here are a bit similar as in the previous location [GY] […] a mixture of many different things, that does not make you think of fresh air,*' while describing the smellscape downstairs as '*Mosses. That is nice. Yes, again a bit the feeling of being away from the city, away from the pollution.*' P_U4 while going up noticed the '*mishmash of smells […] I smell exhaust gasses, I smell smoke, I smell something like metal, and I smell that forest smell*' and going down P_U4 said: '*and now that mishmash is gone again.*'

6.1.3 GREEN: a variety of natural smells is constantly present

The smellscape of GN was clearly dominated by the presence of smells of nature, in particular the smell of soil, decomposing leaves and living plants. These smells evoked almost without exception positive affective responses. Different from both GY and SM, the smellscape was perceived relatively constant and pure, also shown in section 3.2, where GN is the only location scoring significantly more pure. All participant mentioned the smells being constantly present, although the intensity could still vary spatially. The variation was caused by the density of plants and the openness of the spot.

Only once in a while, a smell from human objects was mentioned, such as a cigarette of a passing pedestrian, a whiff of food smell or '*old people*'. However, these remained exception and did not take dominance in the smellscape. This is also shown in section 3.2, where GN scores much higher in naturalness than SM.

Smells in GN and SM were often compared. Participants did perceive similarity in smells of nature in both location, however described differences in their olfactory experience, often considering purity and intensity. For instance, on the notion of purity, P_M1 said to '*have no distraction due to the smell of tires, as that is what we had along the canal,*' and P_M3 said: '*I smell the leaves again. […] That other time [in SM] it was more mixed up […], more mixed with eh, yes, how to say, non-natural smells. This is more natural smells exclusively.*' On the intensity of smells, P_M10 said at the start of the transect: '*Yes, of course I smell a large bunch of leaves again, he. Yes, a bit stronger,*' and P_M2 said in SEMI that similar smells were '*less intense,*' also evoking '*less intense [feelings] than where we just walked.*' P_W8 described it as: '*Here [in SM] the leaves are not as autumn-like in their smell as we just experienced [in GN].*' In short, GN was perceived as '*just more intense*' (P_U5).

The smell of nature being constantly present and being perceived as pure rather than mixed did not equal a monotonous olfactory experience. Participants noticed that different plants emitted different smells. This could be stated explicitly,

such as done by P_U4: *'I smell more nuances […] I really smell a spectrum of smells actually'* and P_W8: *'Not one monotonous smell, it is very diverse as well.'* Other indicated variety more implicitly, by either naming a difference, e.g. *'like life and death'* (P_M1) referring to both green plants and decomposing leaves; or simply by pointing out specific smells, such as *'Hortensias'* (P_M1, P_M3), *'Mushrooms'* (P_M10, P_M3), *'Hedera'* (P_M8), *'Pine'/'Pine-like'* (P_U1, P_U4, P_U6), Taxus (P_M3), Common Snowberry (P_M1) or *'Chestnut'* (P_W2, P_W3, P_W4, P_W7).

The smellscape of GN also scored significantly stronger than both GY and SM (see section 3.2). Despite GN having a strong and dominant smellscape, smells of nature were not perceived as penetrant. So, whereas the smell of cigarettes, exhaust gasses or perfume could be perceived penetrant due to their strength, the smells of nature were still perceived as rather subtle. (Cigarette smoke in GN was also perceived penetrant.) This is also shown in section 3.2 where GN scores highest on calmness. The smellscape in GN overall resulted in much less negative responses and much more positive feelings and association, also shown in chapter 5, by the pleasantness score (section 3.1) and in section 3.2, where GN scores highest on being liked. The positive associations were related to the smells of plants, decomposing leaves and (moist) soil.

There was just one smell in GN that evoked considerable negative reactions: *dog faeces*. Even when dog faeces was not smelled, participant said that they expected to smell it. The eventual reaction to the smell differed. Some participants were not fond of dogs at all or associated it with the undesired human behaviour of not cleaning it, for that interpretated the smell as very dirty. Others thought of it as a bad smell, but judged it rather neutral since they perceived it as a natural smell and part of a park.

6.2 Themes on olfactory experiences

This section describes two dominant themes that are considered most important for the study (6.2.1 and 6.2.2), and three smaller themes that also provide insight in smellscape experience (6.2.3 to 6.2.5). These themes aim to answer RQ1b, RQ1c and RQ2a – and provide insight in answering RQ3.

6.2.1 Smelling, breathing and perceived healthiness

The perception of smell was strongly linked to the perception of air quality and the breathing experience. Participants often formulated the olfactory experience not in smell, but in air quality related terms. Examples being: fresh air, cold air, pressing air, thicker air. One cannot truly smell the density or quality of air, as some participants also noted, yet either a smell triggered the association with air density/quality or the air density/quality triggered an olfactory perception. As P_W7 asks to the point: *'However, is warmth a smell? Or is it just an incidental characteristic of the olfactory organ? Yes, that is a difficult question.'* It shows that the perceptive boundary between

smell through the nose and breathing trough the nose was rather blurred and flowed into each other. A few examples will illustrate it clearly.

Often, the smell of exhaust gasses was associated with an impaired breathing potential. For instance, P_W5 said: '*Yes, now I smelled the exhaust gasses from the car passing by. […] Yes, it takes your breath away a bit. You feel that you get less oxygen inside your lungs.*' In similar fashion, P_W6 disliked the smell of smoke, '*because it is a very penetrating nose feeling. And it remind me of not-breathing.*' P_W7 and P_W9, described the musty city smell as being '*stuffy*' or '*still air*', associated with negatively perceived air quality.

On the other hand, participants experienced fresh air, again sometimes unsure whether this was an olfactory or a breathing experience, which not rarely was brought into relation with urban green elements. Examples from *fresh air* experience are to be found in section 6.1.2. Other examples are that participant noted that the smell was '*open*', '*free*' or '*clean*'. These air characteristics were often brought into relation with a pleasant breathing experience. For instance, P_M2 in GN said to notice '*that there is more oxygen in the air, that directly makes your mind open. And that is a combination, smell and visual.*' Here, P_M2 indicates clearly the blur between senses and breathing.

The association with health and unhealth played an important role in the link between olfactory perception and breathing experience. Smells such as car engine, exhaust gasses, cigarettes and brackish water were linked to the harmfulness of substances for humans and/or the environment. The smells of fresh air and natural elements on the other hand, were linked to healthy air quality. Thus, the smells gave participants information on the healthiness of the environment, which related to the perceived quality of the urban living environment.

As such, there was a triangular relationship between: olfactory perception (e.g. exhaust gasses, nature) and information on healthiness (e.g. stuffy, clean, oxygen) and the breathing experience (e.g. impairment, free). (It is to note that two elements of the triangular relationship occurred without the third, for instance, olfaction was formulated in terms of air quality without the association with health.)

Smells in GY were most often linked to unhealthy environmental characteristics. Although other participants experience fresh air in GY, and associated that with *outside air* and a refreshing morning. SM was most often linked to healthiness, through the experience of fresh air and openness. Although in SM this experience could change rapidly to unhealthy by the presence of cars. In GN, both healthy and unhealthy characteristics were mentioned less than in SM. In general, human-induced smells were more linked to an impaired breathing experience, hence to unhealthy air quality, whereas natural elements increased the perception of a healthy breathing experience and environment.

6.2.2 Smelling more-than-urban nature

In accordance with the goal and set-up of the study, nature was a salient element in the perceived olfactory landscapes. Nature was mentioned as a description of the smells perceived, as an association with the smells, and as an experience in itself.

Although the fact that *nature* was named as a description of the smell may seem obvious, it does indicate something about the olfactory perception. Participants smelled natural elements in a cityscape, such as trees, grass and plants, but these elements do not equal *nature as such* (or a natural landscape), yet that is what participants said to perceive through olfaction. A more tangible example is *forest smell* as a description of olfactory observations: participants did not smell a forest, since there was no forest, but trees could still *smell forest*. Forest and nature were also often referred to as either an association or the décor of a memory.

The notion of nature was dominant in GN more so then in SM. However, the description of *forest smell* and the association with forest occurs equally frequent in SM and in GN, despite SM was predominantly paved and dominated by cars quite often. Participants associated the smells of nature present in SM with for instance '*walks through the forest back in the days'* (P_M3); '*forest and just, not really paved, but really the, yes really the soil.'* (P_W5); and '*Back in the days I often went to the forest with my mother and grandmother'* (P_W2).

It is not hard to guess why an urban park landscape full of trees reminds one of the forest, since there is some visual similarity and apparently olfactory similarity. Yet the cityscape of SM did not have such visual similarity with an forest, and still a rather strong olfactory similarity between SM and a forest was noticed. '*Yes, rather a forest smell indeed,'* said P_U1; and '*the same forest smell'* , said P_U4. Another example, the smell of decomposing leaves in SM was interpreted as a '*beautiful elements of nature'* (P_M8) and as '*nature has done its job'* (P_M9).

The olfactory experience of nature in SM could be strong enough to constitute an experience of being in nature. For example, P_U2 said that '*It makes it feel natural. That it, it fills something. If I had to describe the smells here, it is a lot of, nothing […] sterile stones […] and once in a while you smell the leaves and it feels like there still something not-human here. It makes it more natural […] and therefore less man-made.'* Further, the smells of nature could become dominant over human induced smells, giving participant '*the idea that you are away from the city, away from pollution. Not that this is true, but…'* (P_U3); or '*the idea that you are outside, in nature. You notice you are surrounded by trees, and by shrubs'* (P_M6); or '*something like connectedness with the seasons. Even though you are walking in the centre of the city'* (P_U5).

However, it should be noted that while this occurred in SM, but was not the dominant experience in SM. As described in section 6.1.2, SM was characterised by a mixed smellscape including human object as well as natural elements.

In GN, similar associations were made by the participants: being in nature, walking in the forest, being outside, natural processes and so on. Also, participants had similar experiences of *being in nature* while actually being in a cityscape. In

contrast to SEMI, these associations and experiences were dominant in GN, due to: 1) a higher frequency of such associations and experiences; 2) the intensity and duration of such experiences; and 3) the lack of other associations and experiences in GN. This is also shown by the questionnaire scores, where GN scores significantly higher on most of the qualities (section 3.2).

Above mentioned (olfactory) experiences of nature generally evoked positive affective responses, sometimes explicitly named *positive feelings*, and other times more specifically, e.g. calmness, happiness and clarity of mind. In accordance with the higher frequency of above mentioned associations and experience in GN, the frequency of such affective responses were mentioned was also higher in GN. Some participants also noted that the positive response to smells of nature were more intense in GN, because there were no cars in GN or simply because the smell was more intense. However, many participants also expressed to be unsure whether these feelings were evoked by the visual or the olfactory stimuli, since this boundary was blurred in their multisensory experience. This notion will be further elaborated upon in section 6.4.3.

A few times however, participants linked negative associations to the experience of nature, mainly because the urban park was perceived in relation with human disturbance. P_U2 mentioned to distinguish the typical smell of '*city park soil',* which made P_U2 '*a little sad*' since it '*reminds of damaged nature.*' P_W9 said he '*always have the feeling of walking in some sort of artificial nature.*' In the same line of thought, some participants mentioned not being in nature completely due to the presence of human disturbances. For instance, P_M5 said to '*always be conscious of the sound of cars here. Thus, you miss the real calmness,*' and also P_U3 said to '*still smell the city slightly […] maybe it is pure imagination.*'

6.2.3 Smelling connects one to the season

The decomposing leaves, possibly together with moister and colder air, highlighted for many the seasonality of nature. This commonality in the data relates closely to the previous theme (section 6.2.2), but has a different narrative to it. Mentioning autumn was not about being in nature per se, it rather indicated the perception of or connectedness to seasonality.

The natural processes typical for autumn, mainly decomposition of leaves, were the olfactory trigger to perceive seasonality. Participants referred to the dawn of autumn after smelling those decomposing leaves, as for example P_W3 said: '*It is like autumn has really started,*' or P_M4: '*It smells like this season smells, ey, it is autumn.*' Some went on explaining the processes of nature during autumn, ending with some admiration for it.

The interpretation of the dawn of autumn did very among the participants and was determined by their association. The interpretation could be divided roughly in three categories: loving autumn and its cosiness, experiencing a form of insecurity and having these feelings mixed. Most participants associated the smell of autumn with

having a comfortable time inside, cooking with ingredients typical for the season, a refreshing forest walk or the beauty of autumn colours outside. Some participants however, had a feeling of slight fear, because the summer was ending. For them, winter was related to gloom or melancholy. Other participants associated autumn with both beauty and melancholy.

6.2.4 Smelling nature evoked many memories

Memories and associations with childhood were evoked by many different smells – including so-called Proustian memories: involuntary yet bright and deep memories. The participants, with one exception, experienced positive feelings due to the memories. Whether it was water evoking the childhood memory of *'swimming as a child'* (P_U3); the smell of leaves evoking the memory of '*puttering with leaves on primary school'* (P_M11); or the smell of cigarettes evoking the memory of *'When I walked through cities with cigarettes and cameras […] in Tokyo'* (P_W8); these memories came with a positive feeling. The only exception being memories evoked by dog faeces: these were associated with '*very bad experiences'* with dogs (P_M10) and '*that […] mom got angry'* (P_M1).

So, smells that were judged negatively over all could still evoke positive memories for specific participants. Such memories often caused either a moderated or positive attitude. For instance, P_W4 expressed to judge the smell of exhaust gasses '*kind of pleasant, actually rather good,'* because of the memories of working in a garage and going to the circuit. Hence, the interpretation of smell partly depended on the memories.

There was one commonality within memorising: smells of nature evoked relatively many memories by the majority of the participants. Most of these memories going back to childhood, such as '*Sunday afternoon walks with my family'* (P_M10), '*the village I grew up […] where they blew leaves on a big pile and then as a child playing in those piles,'* (P_U2) and '*my grandfather had a chestnut tree back in the day'* (P_W2). These memories coming with positive affective responses. The positive feelings evoked by memories related to nature were not more positive than feeling evoked by memories related to non-natural sources; but in this study, the green elements in the cityscape evoked positive memories more frequently and commonly.

In a few isolated cases, the memories were place-specific. These participants indicated to walk regularly in the urban park, location GREEN, and memorised about their previous walks in other seasons. Especially in Middelburg, several participants noted that they loved the park looking different every season, a characteristic you can see and smell, they said.

6.2.5 People: negative when harmful, cozy when warm

Whereas smells of nature uniformly evoked positive affective responses in this study – through associations, feelings, experiences or memories – the smells from non-natural sources were interpretated either positive, negative or neutral. The interpretation of

non-natural smells was highly dependent on the associations with the smell. It is already discussed in section 6.2.1 that smells related to unhealthy effects were generally perceived negatively, and in this study most smells from non-natural sources are within that category.

However, smells from houses, food and fireplaces were associated with human life in a positive way. The typical and hard to translate Dutch word *gezellig* was often named in relation to such smells – meaning something like cosy combined with sociable and comfortable. '*That is what I like of being in the city, that you can smell that people live,'* said P_W1. In similar fashion, P_U6 after smelling food being prepared said '*that it gives like a… feeling of "gezelligheid", that there are more people here.'* This positive association with human and people's living occurred only in GREY and SEMI, since the smells triggering these associations were not present in GREEN.

6.3 Smellscapes with natural elements are preferred

Participants compared the three smellscapes to answer to the last interview question – and sometimes along the transect as well – and named notable similarities and differences among the location. The majority of the participants indicated that they perceived notable difference in smellscapes among the location. Some expressed being slightly surprised by the differences in smells on such small spatial scale. After having experienced all three locations, the participants were asked to express their smellscape preference.

The perceived differences were mostly related to the extend to which urban nature was absent or present and presence of cars. Both the difference between GY and SM, and SM and GN was mentioned. Participants formulated it for instance as '*contrast with nature's smell'* (P_M1), '*there is a completely other smell here'* (P_W5), *'earlier it was a bit plain'* (P_U4) or another adjective assigned to the previous location (e.g. minimalistic, fuller, better, more pure). In general, participants indicated that the smellscape was influenced positively by the presence of urban nature, using words as *pleasantness, nice, deeper and happiness* – indicating positive affective responses – and by describing experiences of nature.

Participants also experienced similarities between SM and GN. Mostly due to the smell of decomposing leaves (the 'forest smell') and the smell of plants. Some said that SM and GN together contrasted with the plain smellscape of GY. Despite the perceived similarity, the majority indicated that the smellscape of GN was richer and that the positive elements of SM were more intense and/or more constant in GN.

Reasons for smellscape preference can be divided in two main categories: 1) the most positive affective responses, mostly as pleasantness, freshness or calmness; and 2) the perception or experience of nature in the landscape. Aside from that, specific reasons were sometimes named.

22 out of the 25 participants preferred the smellscape of location GREEN. Common reasons for this preference were: the most calm smellscape, the most natural smells, the most fresh smellscape, the feeling of being in nature/being away or because it had the most pleasant smells. Some participants had very specific reasons, such as the evocation of childhood memories, having a connection to place or connectedness with the seasonality.

3 participants preferred SM for specific reasons. One of them admitted that he had a strong a priori preference and connection with the place and therefore experienced everything there more pleasantly. Another loved the openness of SEMI's landscape, and thought of GREEN's smellscape as slightly too dense. The third one said to prefer SEMI because it had smells of nature *'without the undertone of dog shit.'*

6.4 Themes on general Olfactory experience

This section presents three themes that were expressed in participants' own reflection on their olfactory perception. The study did not aim at yielding these results, yet they are noted as a step towards the interpretation of the other results in section 7.2.

6.4.1 More pronounced focus on olfaction than usual

The majority of the participants (16 out of 25) indicated that their olfactory awareness was different from their everyday olfactory awareness. This could be framed in two different ways:

1) A positively expressed realisation that more smells than expected are present in the living environment, possibly accompanied by an increased awareness of the effects of smells on the experience of the living environment. Participants said to be surprised or said they never considered the olfactory environment.

2) The realisation of lack of smells in the environment. This realisation was less common than the previous one. Some of them suggested that it was a post-covid symptom.

Ironically, both groups of participants mentioned similar amount of smells or smell categories.

Four participants said they had to actively search for smells and that this active search felt slightly forced. Indicating above all that their smellwalk experience did not represent their everyday olfactory consciousness. Three of the four people saying this were smokers (2 of the 3 smokers in the study) or had smoked a lot in his life. However, no significant differences were found between smokers and non-smokers in the questionnaire data.

The majority of the participants indicated to have enjoyed the smellwalk experience and/or that they had an interesting experience. Mainly due to the increased awareness of smells. Two participants expected that the smellwalk would give them an permanent new perspective on the living environment. Three participants experienced

the smellwalk as a mediative experience in itself, and one of them continued doing smellwalks with walking buddies.

6.4.2 Not always able to explain judgement

Participants not rarely expressed difficulty with putting their olfactory experience into words; 14 out of 25 participants mentioned this at least once. Participants had difficulty with describing the smell, not being able to trace the smell back to a source and resulting in an undefined smell or vaguely described one. In some of these cases, the participants explicitly stated to search for the explanation of the smell with their visual sense. This is further discussed in section 6.4.3.

Participants also had difficulty with substantiating their initial judgement of a smell. Sometimes they just reacted negatively or positive to a smell without knowing why. A few participants reflected on this experience themselves, for instance P_W4 said: *'I don't know how you can describe whether a smell is pleasant of not. That is just something hardwired in your brain or something like that,'* and P_M5 said: *'Of course we are conditioned to think that.'* Related to the inability to explain their reaction to the smell is the notion of an instinctive reaction. A few participants indicated to have an instinctive negative reaction to a smell, whereas other indicated an immediate reaction of e.g. *'the urge to walk away'* (P_M8).

6.4.3 Multisensory essence of landscape experience

Participants regularly mentioned the visual and auditory dimension of the landscape during the smellwalk. Sounds from the surrounding soundscape were mentioned three times as a disturbance of the olfactory experience. The sounds then distracted the participants from their sense of smell and caused a less calmer experience.

The visual landscape was talked about quite often. Section 6.4.2 explained one context in which the visual was mentioned: to search for the source for smell. In these cases, the smell itself did not provide enough information for the participants to identify the source of smell. Only after tracing the smell back to its source visually, they understood the smell. One participant mentioned it the other way around. The participant had just been recovered from the lack of smell due to a corona infection. He explained that the lack of smell made his subjective experience separate from the environmental experience. He could see the environment, the objects in the environment, but only after smelling them again he was really conscious of the environment and the object in it.

Other participants mentioned the role of smell in the total multisensory landscape experience, either the smell got its meaning due to the multisensory landscape experience, or smell contributed to (the feelings evoked by or meaning of) the multisensory landscape experience. The visual could also influence the interpretation of smell: e.g. autumn smell could be less intense, *'because there are cars'* (P_W5).

More common however, was an indication that the boundary between sense of vision and the sense of smell was rather blurred. Not rarely, participants said a phrase like *'it is the combination of smell and the visual'* (P_M2, P_M5), or a phrase of equivalent meaning, such as *'also the environment visually'* (P_M8). Sometimes it was explicitly mentioned that it was hard for a participant to divide the visual and the olfactory impressions, also having difficulty determining whether the visual or the olfactory was the cause of evoked feelings.

It also occurred several times that participants described a visual perception as their olfactory perception. For instance, the colours and the smell of autumn leaves were often mentioned in one observation, almost as if the colour was the smelled object (this was explicitly stated once); or the general visual impression of 'openness' was mentioned as a smell (*'It smells nicely open'* (P_M11)).

The multisensory nature of the participants' landscape experience is also backed by the landscape experience of P_M7. P_M7 has been removed from the data, since P_M7 recovered from a corona infection close to the study's date and his sense of smell was completely absent. He was not able to smell anything at all, yet he described his experiences briefly. P_M7 described the urban park as calming and experienced *'a bit of happiness'* due to *'the different colours, because that is the season.'* P_M7 too associated the urban park with the expectation that it would smell clean. Whereas in SEMI, seeing cars, he said to associate the location with less freshness, being less clean. Similarly in GREY, he said: *'the air is less clean. That is what I expect.'*

Hence, while not describing it as elaborative as the other participants, P_M7 mentioned several associations also mentioned by the smelling participants, solely based on visual cues and expectations. However, not all associations were also made by P_M7, as e.g. the notion of forest, natural processes, nature, fresh air and other specific descriptions of air quality and breathing experience were not elaborated upon by him. Of course, P_M7 remains a single data point in the study and can therefore not be used as a full comparison.

7 Discussion

This study aimed to contribute to the understanding of how urban nature contributes to a living environment that promotes human wellbeing through landscape experience and preferences, by exploring the in-situ olfactory perception of different urban green settings and the contribution of this perception to smellscape preference and human wellbeing.

The main findings can be summarised as follows: urban nature added various olfactory perceptions to the smellscape; these elements were perceived as olfactorily more pleasant than "grey smells" and scored higher on 7 of the 9 olfactory quality scales; wellbeing scales were scored highest in GREEN; olfactory perceptions of urban nature were associated with healthiness, being in nature and seasonality; the GREEN smellscapes were generally preferred and this preference was caused by either positive affective responses or the experience of nature. However, the multisensory essence of landscape experience and a more-than-usual focus on olfaction were noted by participants.

This chapter will discuss the methodological limitations of my study and their influence on the findings and put my findings in a broader theoretical context.

7.1 Smellscape experience and preferences

The results clearly show how three different smellscapes are experienced differently by the participants. Urban nature seems to influence the perceived smellscape elements, characteristics and evaluation considerably. Personal data did not seem to influence the data (section 3.3) and is therefore considered irrelevant for this research. This section discusses and interprets the results on smellscape perceptions (chapter 5 and 6), evaluations (chapter 3 and 5), experience and preference (chapter 6). The olfactory pleasantness framework used critically discussed in relation to the qualitative data.

7.1.1 Spatial and temporal specificity

Smells have high spatial specificity: the cityscape elements logically determine which smells can be perceived. My study's data was yielded in only three Dutch city centres.

Therefore, results of the study cannot easily be generalised to other locations (Verma et al., 2019). However, by focussing on the perceptual patterns of smellscape perception, the study provides results somewhat separated from the place specific elements. Nevertheless, similar studies in different cityscapes are necessary to confirm or adjust these perceptual patterns.

Furthermore, smells of nature have strong temporal specificity, as each season smells differently (Henshaw, 2013). The study was conducted during autumn, in a time frame of 7 weeks and under specific weather conditions. Without doubt, the specific conditions determined the smellscape for a large part: vegetation is complete different during spring and summer and even at the end of autumn compared to its beginning; temperature influences the intensity of all smells; and precipitation and wind influence the dispersion of smells. Therefore, further research is needed in different weather and seasonal circumstances to get a better understanding of smellscape perception.

Another weakness is that the data was yielded in *three rather than one city*, due to the limited resources available for the study. This was justified by an earlier study stating that perceptual patterns in different cities are similar (Xiao et al., 2018). The smellwalks were conducted along comparable transects, to ensure comparability in the perceptual patterns. Despite several individual city-specific perceived smells, the results indeed do not show any difference in the perceptual patterns between the three cities.

The choice of the three categories of cityscapes was a priori and subjectively chosen by me: GREY, SEMI and GREEN. Of course, this choice determined the perceptual patterns within that location. It was intendent to have very few natural elements in GREY, natural elements in SEMI and a urban park in GREEN, and results were yielded according to this set-up. It was not known beforehand to which extend urban nature would influence the smellscape, but the results confirmed the set-up's assumption that nature would have influences on the smellscape. Further studies could apply a gradient approach rather than a categorical approach. For instance, smellwalks can be conducted along random transect, with a posteriori determination of amount of green through GIS, to prevent the bias of a priori categories.

7.1.2 Smells and olfactory pleasantness

Participants, except for P_M7 who recently had a covid infection, were clearly capable of distinguishing and judging different smells in the cityscape, which is in accordance with the theory in the introduction. Participants had three difference smellscape experiences. Furthermore, the differences caused by urban nature were expressed frequently and saliently.

In agreement with the theory described in the introduction (Yeshurun & Sobel, 2010; Khan et al., 2007; Nasar, 1989; Kaplan & Kaplan, 1989), the notion of pleasantness dominated the judgements of smells, as most judgements expressed a degree of (un)pleasantness in different formulations. Language and experience are related in the sense that language interpersonally communicates and informs about experience – without being one-on-one representations of each other (Jacobs, 2006).

Therefore, the wordily expressed degrees of (un)pleasantness represent approximately the affective responses to smellscape stimuli.

Results presented in chapter 3, 5 and 6 are comprehensible once placed along the perceptual axis of pleasantness. The results suggest that urban nature increases the perceived pleasantness of the urban smellscape. Urban nature brings smells to the smellscape perceived as pleasant to very pleasant, generally resulting in positive affective responses (expressed as feelings). Human-induced smells dominating in grey smellscapes were generally rated less pleasant. However, pleasantness alone is not enough to understand the full olfactory landscape experience. Both the olfactory quality scales (Xiao et al., 2018) and the qualitative data provide more in-depth insights.

7.1.3 Olfactory quality scales: methodological considerations

The olfactory quality scales used were formulated by Xiao et al. (2018) to explain olfactory pleasantness. Adopting the framework came with the assumption that the study of Xiao et al. (2018) is reliable, that their nine olfactory qualities cover olfactory pleasantness rating and that the olfactory qualities have a linear relationship with olfactory pleasantness. However, the results show that adopting the framework came with several limitations.

The results show a significant, yet moderate correlation ($r_{(73)}$=0.4-0.7) between seven of the olfactory quality scales and olfactory pleasantness rating: calmness, naturalness, liking, purity, freshness, intensity and cleanliness. These results, except for intensity, are in accordance with the results of Xiao et al. (2018).

The intensity score was positively correlated with pleasantness. This is contrary to Xiao et al. (2018, p.110) who concluded that 'participants found high intensity of smells unpleasant, no matter liked or disliked.' My results disagree with that conclusion. Smells of nature were perceived as both intense and highly pleasant, whereas exhaust gasses as intense and highly unpleasant. These results suggest that the relation between intensity and pleasantness is depending on the smell being liked or disliked. This is in accordance with research showing that both negative and positive correlations occur, depending on the judgement of the smell (Distel et al., 1999; Moskowitz et al., 1976). Hence, the relationship between intensity and pleasantness is more complex than assumed and influenced by several factors.

The scores on expectedness and familiarity did not show a correlation with pleasantness – Xiao et al. (2018) used 'appropriateness' instead of 'expectedness': the extend to which a smell fits in a certain context; a detail lost in translation – which is not in line with earlier studies that did find this relationship (Xiao et al., 2018; Distel & Hudson, 2001; Distel et al., 1999; Jellinek & Koster, 1983). Whereas no correlation was found, the qualitive data indeed indicates that the appropriateness of a smell or being used to a smell (familiarity) moderates negative judgement of smells. This suggests that the relation between expectedness and pleasantness is not simply linear, but that expectedness rather functions as a moderator. Another suggestion is made by

Delplanque et al. (2008): the relation between familiarity and pleasantness depends on biological relevance and survival. The results agree with Delplanque et al. (2008): smells associated with harmful effects were perceived familiar, yet very unpleasant.

Other olfactory quality scales also seem to have a more complex relationship with pleasantness than assumed by the used framework. For instance, GREY (GY) and SEMI (SM) scored similar on the dislike-like scale, yet the interview revealed the smellscapes being liked differently. Possibly this discrepancy is caused by the mixed smellscape of SM, including smells highly liked and disliked resulting in a neutral average score. Whereas the neutral average score of GY is probably caused by the large absence of smells. Another example, GN scored rather pure, while participants noted a variety of natural smells; GY scored anywhere from mixed to pure, because it could consist of either many whiffs or none at all; indicating different interpretations of the word "pure". On the weak-strong scale, where GY scored anywhere from very weak to very strong, probably depending on the amount of penetrating whiffs perceived by the participants. Therefore, this scale does not capture the smellscape truly and separating the background smell and the whiffs of smell would provide better insight.

The olfactory quality scales used failed to capture the full olfactory experience by reducing it to a simple linear relation between an olfactory quality and pleasantness. Above all, this limitation shows that it was right to assume that a mixed methodology was needed to explore the olfactory perception of urban smellscapes and to enrich the questionnaire data with qualitative phenomenological data (Berg, 2007; Kvale, 1996; Seamon, 1982). Not withstanding, the questionnaire scores give a good overview of the general smellscape experience that can be used in shaping a protocol for a large scale study (Xiao, 2018), but based on my study, the scales need some refinements and/or sub-scales –conceptualising these is outside the scope of my study.

7.1.4 Qualitative data: subjective associations, the research population and innate responses

The qualitative data revealed underlying patterns of emotions and associations explaining the patterns in affective responses to smellscape stimuli in more detail than the questionnaire scores alone. The interview data and thematic analysis gave insights in reasons for olfactory pleasantness and smellscape evaluations (chapter 6).

In my study, smells of nature evoked positive affective responses without exception, whereas human-induced smells evoked positive and negative affective responses. However, it is to note that my study only included spatial and temporal specific smells of nature that evoked these responses, whereas other smells of nature, e.g. a dead animal, presumably evoke less positive responses.

7.1.4.1 Individual and cultural constructs and the limited research population

The affective responses to smellscape stimuli depended highly on positive or negative associations and individual-specific memories. For example, the smell of cars that was judged positively when associated with positive memories and negatively when associated with harmful effects. Indeed, olfactory perception is highly influenced by individual memories (Stevenson & Boakes, 2003).

My results are in line with the dominant view in literature that olfactory perception is largely determined by individual experiences and cultural conventions (Baccino et al., 2010; Herz, 2006; Chrea et al., 2004; Candau, 2004; Wrzesniewski et al., 1999; Rodaway, 1994; Engen, 1991, 1983; Schleidt et al., 1988). Per example, Hickman (2022) provides a detailed historical analysis of pine smell. The smell of pine has evolved to have a cultural meaning of cleanliness and health, partly due to institutional use of pine scent for healing purposes.

Thus, olfactory perception is influenced by norms, values and previous experiences (memories). This suggests that e.g. the smell of cigarettes in this study was judged negatively because the contemporary cultural norm holds that smoking is a harmful habit that needs to be removed from society. Also, the positive feelings evoked by natural smells, such as happiness and calmness, could be caused by previous association with nature, such as holidays in the forest.

The limited research population in my study is a major limitation in the context of olfactory perception being determined by individual and cultural constructs. The final research population was determined by data saturation (see section 2.1; Saunders et al., 2018), which according to me was reach, since qualitative data became repetitive and participants did not add new information. Despite the research population was skewed towards younger people with relatively high educational background, it did not seem that the older or less highly educated participants added different of new information.

However, the research population was bias-sensitive due to the snowballing sample strategy and its limited size of 26 participants. People with lower educational background were highly underrepresented and various demographic groups were not present in my sample at all, to name a few examples: lower educated older people, people from low-income neighbourhoods, people with a migration background or people from non-Dutch ethnographic groups. More importantly, the study was conducted with solely Dutch people in the context of Dutch landscapes.

The results of my study are not generalisable to other demographic groups and cultures without consideration, since individual and cultural constructs can highly influence olfactory perception. Further research is certainly necessary in other cultural contexts to either confirm or adjust the perceptual patterns found in this study at a cross-cultural level.

7.1.4.2 Innate responses to olfactory stimuli

Studies have also suggested that olfactory perception can be partly innate (Khan et al., 2007), since different cultures can have similar pleasantness ratings to smells (Candau, 2004; Chrea et al., 2004; Schleidt et al., 1988). The innate olfactory perception is suggested to be deeply rooted in our evolutionary biological being (Sela & Sobel, 2010; Soussignan et al., 1997), e.g. for survival (Delplanque et al., 2008) or preventing incest (Weisfeld et al., 2003). These possible innate (emotional) responses to stimuli may occur outside the consciousness of the perceiver (Yeshurun & Sobel, 2010; Jacobs, 2006).

Despite finding clear patterns of associations and affective responses, it remains unknown whether these are caused by subjective constructs or evolutionary responses – although based on my results from the thematic analysis and theory mentioned in section 7.1.4.1 it can be assumed that a large part is based on subjective constructs and individual memories. In fact, I only collected data on olfactory experience as communicated by subjects themselves. Hence, the notion of evolutionary responses to smell is completely absent from my data and other methodologies are needed to study relations between innate olfactory perception and smellscapes.

7.1.5 Landscape preferences

Participants expressed a clear smellscape preference for smellscapes containing (elements of) urban nature. Smellscape preference had two main reasons based on participants' own indication and the thematic analysis, namely 1) the most positive affective responses on elements of nature in the smellscape, mostly in the form of pleasantness, freshness and calmness; and 2) the experience of being in nature in the cityscape. These results suggest that, similarly to visual landscape and soundscape preference, natural smellscapes are preferred as well.

According the theory in the introduction, preference implies among other thing satisfaction of needs. Determining which needs are satisfied by the preferred smellscapes, is outside the scope of my study and data. According to Kaplan & Kaplan (1989), these needs can be based on evolutionary patterns. In short: people prefer natural environments because we are evolved to like them for survival. This is in line with the biophilia hypothesis, which hold that people have an innate affection for nature (Kellert & Wilson, 1993). The results of the current study can be explained by the biophilia hypothesis, as such assuming that humans have innate preference for smells of nature.

However, as described in detail by Jacobs (2006), this theory neglects the cultural dimension of landscape preference. Jacobs (2006) also illustrates that medieval cultures had a negative perception of nature, hence no preference for natural landscapes, suggesting that cultural norms prevail over innate affection. My results indicate that Jacobs is right. Despite smellscape experience may be partly explained by biophilia, the perceptions in the study were majorly influenced by individual values and associations. For instance, the value participants placed on

humans and nature determined their smellscape perception, as became clear in the qualitative data.

Hence, it remains unknown whether smellscape preference are partly innate, substantiated by Kaplan & Kaplan (1989) and the biophilia hypothesis (Kellert & Wilson, 1993); or completely culturally and subjectively determined (Henshaw, 2013). What can be stated with certainty, is (1) that the feeling of being in nature was expressed as a reason for smellscape preference; and (2) that smellscape preference is linked to emotional and affective responses to smellscape stimuli, that olfactory perceptions of natural elements evoke positive affective responses, and that these are at least partly formed by individual and cultural associations. Due to the latter, the smellscape preference results can also not be generalised across cultures and demographic group (see section 7.1.4.1 for argumentation).

7.2 Multisensory perception and awareness of smell

Two notions on the olfactory perception itself became salient in my study: the multisensory essence of participants' landscape experience and participants being more aware of olfactory stimuli during the smellwalk than usual. Interpreting these notions provide insight in how representative my results are for mundane life.

7.2.1 Multisensory perception

The methodology assumed that participants were able to describe their olfactory perceptions as isolated perceptions. However, participants regularly needed visual information to explain their olfactory perceptions and were not rarely unable to trace their feelings back to one sense or the other. This is no uncommon finding. Earlier studies found that descriptions of smells often refer to other senses (Baccino et al., 2010; Shepherd, 2004). Research also showed that evaluation based on affective responses of smells is influenced by source information (Herz, 2003) and smell labelling (Djordjevic et al., 2008).

These notions indicate that the smellscapes experience could be influenced by visual information. Research from the food industry shows that smell identification is determined by the colour (Spence et al., 2010; Yeshurun & Sobel, 2010 and reference therein), per example: orange-coloured cherry flavoured drinks were perceived as having the smell of oranges (DuBose et al., 1980). Colour-odour relations appear to be rather robust, suggesting high-level, complicated cognitive interactions in processing olfactory and visual sensory information (Spence, 2020c; Shankar et al., 2010; Demattè et al., 2006).

The current study found similar results, e.g. participants often referred to the autumn smells and colours as a mixed impression; and participants evaluated the autumn smell less pleasant because they saw cars. This indicates that the olfactory pleasantness is dependent on other sensory information as well, and therefore does

not speak for itself, but is highly contextual in a multisensory landscape experience. Another study found that smells congruent with the visual environment increase the affective response to that environment (Sabiniewicz er al., 2021). Indicating that smell itself is meaningful in the multisensory landscape experience, also expressed by participants of the current study and by Weber & Heuberger (2011).

Similarly, two participants indicated that the sound of cars disrupted their olfactory experience. Suggesting that a similar effect could be described between the auditive and olfactory perceptions. However, because my study did neither focus on sound nor found much data on it, discussing this is beyond the scope of this thesis.

Hence, the results of the thematic analysis could be based on multisensory landscape experience rather than olfactory landscape experience alone. This can be considered a shortcoming in the sense that it does not isolate the olfactory experience and its effects on landscape experience and wellbeing, which may hold that the results may be an overestimation. It was outside the scope of this research to study the senses isolated from each other and to objectively measure biologically affective responses (as e.g. done by Hedblom et al., 2019). Further research could do similar studies, but excluding either the sense of smell, vision or hearing to analyse different inputs more in-depth.

However, the multisensory experience could also be considered a strength, because it increases the representability of mundane life, where people are in essence multisensory beings. According to Spence (2020a), studying olfactory perception of the environment only makes sense in combination with multisensory perception. As such, my results open a call for more in-situ studies to multisensory landscape experience and to go beyond theory based on visual simulations of the environment.

7.2.2 Olfactory attention

By doing a smellwalk, there is necessarily a more-than-usual focus on the olfactory dimension of the landscape (Henshaw, 2013). Despite smellwalks being considered a method to study mundane experiences (Holmes & Hall, 2020; Dowling et al., 2018), it cannot be denied that the olfactory perception during a smellwalk differs from everyday life.

Whether or not the smells have the same effect in everyday life, that is, outside of research context, is hard to answer. Scents are present in the environment, but are not always perceived consciously. Researchers have argued that the everyday olfactory awareness of people is rather weak (Sela & Sobel, 2010; Spence et al., 2001). A study by Forster & Spence (2018) found that more than half of their subjects failed to notice unexpected olfactory stimuli, concluding that olfaction is prone to inattentional blindness when people are occupied in a cognitive demanding task.

Two questions remain: 1) whether the affective responses to smellscape stimuli happening in the biological neural system (Jacobs, 2006) also happen without humans being aware of them; and 2) if so, whether these biological responses influence humans without them being aware of them (Keller, 2011), a question

unanswered until today (Hommel et al., 2019). On this point, the discussion goes into the subject of neuroscience and a philosophical debate on constructivism versus positivism. Hence, going in-depth here is outside the scope of this study. However, the important notion here is that the results cannot be translated one-on-one to everyday life, decreasing the validity of my results.

7.3 Possible contributions to wellbeing

Before answering RQ3 – To what extend does the olfactory experience of urban nature contribute to a landscape that fosters wellbeing? – the results need to be analysed on possible contributions to wellbeing. This section is written bearing in mind the weaknesses described in section 7.2: multisensory essence of landscape experience and changed olfactory attention.

7.3.1 Scores: methodological consideration

The results in chapter 6 show that participants answered with a higher score on the momentary wellbeing questions in SM than in GY, and in GN than in SM. This is line with the many studies that say urban nature contributes to a landscape that promotes wellbeing (o.a Cox et al., 2018; Soga & Gaston, 2016; Bratman et al., 2015; van den Berg et al., 2015; Hartig et al., 2014; Berto, 2014; Hartig et al., 2011; Maas, 2006; Miller, 2005; Hartig et al., 2003).

Participants were asked to answer the questions while focussed on the olfactory dimension of the smellscape. However, it is invalid to link these outcomes to the olfactory perception of urban nature in the cityscape per se. As discussed in the thematic analysis and section 7.2.1, participants were unsure whether to trace their feelings back to olfactory or visual cues, making it impossible to hold olfactory perception of urban nature responsible for the increase in momentary wellbeing. This notion is backed by the statistical analysis: the wellbeing scores correlate equally with visual pleasantness and olfactory pleasantness.

Hence, there is simply not enough evidence to link the results of chapter 6 to the olfaction of urban nature. Therefore, they will not be used to answer RQ3. The results of chapter 6 at most suggest smell being part of multisensory contact with nature fundamental to its restorative capacity.

7.3.2 Health and satisfaction

The results of the current study indicate that olfactory perception leads to a perception of air quality, through the associations with breathing experience, health and harmful effects. As such, olfactory perception could play a role in the perceived quality of the urban living environment (see introduction section 1.1.1). The perceived quality of the urban living environment is a main factor in residential satisfaction (Mouratidis, 2020; Parkes et al., 2002; Van Poll, 1997) and quality of life (Francescato, 2002), hence in

residents' wellbeing (Aragonés et al., 2017; Vemuri et al., 2011; WHO, 1998). As such, the olfactory dimension of landscape experience can influence residential satisfaction, quality of life and wellbeing.

Perceived environmental qualities that contribute to residential satisfaction and wellbeing are environmental health and upkeep/care (Frumkin, 2003; Bonnes et al., 1997). The current study shows that the olfactory perception of urban nature was associated with freshness, health and cleanliness. Cleanliness was also found earlier as a main perceptual dimension of urban nature (Gobster & Westphal, 2004). By altering the perception of environmental quality and health positively, smelling nature could be a perceptual pathway through which urban nature contributes to a landscape promoting wellbeing.

Furthermore, olfaction led to perceiving bad air quality and air pollution. Previous research showed that pollution leads to a badly perceived environmental quality (Hassine et al., 2014; Bonnes et al., 1997). The perception of unhealthy and harmful smells evoked negative feelings. This can be seen as annoyance: a feeling of displeasure caused by disturbance (Lindvall & Radford, 1973), which has long been acknowledge to impair wellbeing without causing actual physical harm (Van Poll, 1997; RIVM, 1988; Winsemius, 1987). Research showed that disturbance/annoyance caused lower perceived health (Van Kamp et al., 2003), fear for harmful effects and anger (Rinck et al., 2011) and lower residental satisfaction (Aragonés et al., 2017).

The phenomenon of the Sick Building Syndrome illustrates that olfactory perception alone is sufficient to impair wellbeing. Studies found that people experience various symptoms while objective measurements found no harmful substances in the air (Donnell et al., 1989). It was concluded that the symptoms were caused purely by olfactory perception of air quality and unusual odours (Spence, 2020a; Wargocki et al., 2000; Donnell et al., 1989).

A study in hospitals found that the absence of smells plays an important role here as well (Stenslund, 2015), because it indicated the removal of disliked smells. Furthermore, the absence of smells constitutes an impression of cleanliness (Stenslund, 2015). This in line with the current study, wherein smellscape GREY could be experienced as fresh, as long as no penetrating other smells were present. Therefore, removing negatively perceived smells from the smellscape is expected to have a similar effect on perceived cleanliness as adding natural elements.

7.3.3 Experience of nature and restorativeness

Another main theme was the experience of nature through olfaction. Participants often indicated to smell forest or nature, also in SEMI locations when visually surrounded by built up area. Associated with those smells were natural processes (e.g. decomposing leaves, seasonality) and the feeling of being away from the city (although being in the centre of a city).

7.3.3.1 Contact with Nature

Experiencing nature is a central concept in nature's contribution to wellbeing, and includes anything from (sensory) contact with nature to cultural perceptions of nature to a deeper feeling of connectedness to nature (see Clayton et al., 2017 for full conceptualisation). Mayer et al. (2009) stress the importance of exposure to nature in order to feel connected to nature and to facilitate a positive effect on wellbeing. Indeed, sensory contact with nature is proposed as a pathway to nature connectedness (Lumber et al., 2017). Visual contact with and exposure to nature has been the main topic of research (see introduction).

The results from my study suggest that olfactory contact with nature is another contact pathway to be exposed to and experience nature. Participants clearly perceived nature through olfaction, either by smelling natural elements, processes or more-than-urban nature (section 6.2.2). As such, olfaction exposes one to the nature in the cityscape. My research thereby substantiates and contributes to the upcoming yet small body of research suggesting that experiencing nature happens though all senses in synergy (see section 1.5). In previous research, sniffing and touching nature appeared to contribute to meaningful contact with nature (Colléony et al., 2020); and smell of forest lowered heart rates and triggered neurological responses in VR circumstances (Hedblom et al., 2019).

7.3.3.2 Naturalness and restorativeness

My results suggest that olfactory perception of nature contributes to the perceived level of naturalness. For instance, the association with forest represents a form of naturalness not truly present in the city, yet participants expressed to perceive it olfactorily. Smells of nature could evoke the feeling of being in nature or being away, while walking through a build environment. Furthermore, the associations made with natural processes and seasonality suggest that the smell contributes to the perception of nature itself.

Previous research aimed at unravelling the why and how behind the strong correlation between nature and wellbeing has shown that being in nature has a restorative effect on mental functioning, which also reduces stress (Bratman et al., 2015; Kaplan, 1995). Studies suggest that the perceived level of naturalness has a positive correlation with the perceived level of restorativeness in nature (Van den Berg et al., 2014; Carrus et al., 2013). Therefore, the level of perceived naturalness positively correlates with psychological wellbeing (Ode-Sang et al., 2016; Hinds & Sparks, 2011). My results suggest that smelling nature can contribute to perceived naturualness, thus a feeling of restorativeness and wellbeing.

However, further research is needed for hard evidence. The question unanswered in this study is: would the associations with natural processes also be made without olfaction? Would participants also refer to the natural processes of decomposition without smelling them? And if so, to which extend? The answers can

not be found in literature, since most studies are based on photographs. It opens a call for research on multisensory perception in-situ in more depth.

7.3.4 Memories and emotions

In the study, smells of nature evoked positive affective responses and relatively many positive autobiographical memories, often going back to childhood. Plausibly indicating that smells of natures were often present in childhoods of participants (Bruijn & Bender, 2018). Also, smells of nature evoked positive emotions and feelings.

7.3.4.1 Evocation of positive emotions

These memories, with one exception, evoked positive feelings/emotions. This is in line with previous research that found odour-induced autobiographical memories to be more pleasant (Willander & Larsson, 2007) and emotional (Herz & Cupchik, 1995) than other memories. It is suggested that odour-induced memories can be used to enhance health and wellbeing (Herz, 2016). Another study found that odour-induced memories caused slow and deep breathing, inducing comfortableness and pleasantness (Masaoka et al., 2012).

Smells of nature also evoked positive feelings and emotions in general. However, as discussed in section 7.2.1, there is no hard evidence linking these emotions to olfaction alone. Rather, they are linked to the multisensory perception (Spence, 2020a). Yet, several studies performed in the dark, to prevent evocation by visual cues, concluded that plant and flower odours induced calmness and positive mood (Weber & Heuberger, 2011). Another study found smells to induce changes in heart rate and skin conductance – that is, a change in electronic conductively in the skin caused by arousal (Hedblom et al., 2019; Bensafi et al., 2002). Based on these studies, presumably part of the positive feelings evoked during the smellwalk were caused by the smells specifically.

According to the broaden-and-build theory of positive psychology by Fredrickson (2001) and Fredrickson and Joiner (2002), positive feelings and emotions are more than just momentary revivals of pleasantness, rather they are true constituents of wellbeing. These studies put forward a third possible contribution of olfaction perception of urban nature to wellbeing: evocation of positive feelings, by themselves or through autobiographical memories, eventually leading to wellbeing through positive upspiraling (based on Herz, 2016; Fredrickson & Joiner, 2002).

7.3.4.2 Sense of Place not included

Section 6.2.4 describes how some participants had place-specific memories. Participants loved the urban park walked through, since it has different beauty each season. These associations could be smells and seen.

These results indicate that the study excluded an important concept in the people-place relationship and landscape experience: Sense of Place (SoP; Jacobs,

2006; Don & Jacobsen, 2003; Tuan, 1977). SoP is a phenomenological construct of a space (Relph, 1985) and is considered to encompass place experience, place identity and place attachment (Newell & Canessa, 2017). A SoP is constituted by the sensing and perceiving of a place, the associations and associated feelings with a place, memories of that place, and the created meaning of a place (Jacobs, 2006; Hay, 1998; Butz & Eyles, 1997; Tuan, 1977). Combined, these factors create one's attachment to a place (Hay, 1998).

Following this conceptualisation, it can be assumed that the smellscape also plays a role in SoP, the relationship between people and specific places, especially due to the link between smell and memory (Henshaw, 2013). A few earlier studies indeed found that smell can play a role in SoP (Newell & Canessa, 2017; Lin & Lockwood, 2014; Zendehdelan et al., 2013; Knopper, 2002).

However, the current study did not have the right framework and methodology to yield data on people's Sense of Place. Since SoP is said to enhance wellbeing (Sakantamis, 2015; Scannell & Gifford, 2017; Scannel & Gifford, 2014; Lengen & Kistemann, 2012) and the relationship between urban greenery and wellbeing (Knez et al., 2018), future research could focus more in-depth on the role of olfaction in Sense of Place as a possible contribution to wellbeing.

8 Conclusion

This study, as the first to do so to my knowledge, explores the in-situ olfactory experience of urban nature and its contribution to landscape experience and wellbeing. The aim of this research was to contribute to the understanding of how urban nature contributes to a urban living environment that promotes human wellbeing through landscape experience and preferences, by exploring the in-situ olfactory perception of different urban green setting and the contributions of these perceptions to smellscape preference and human wellbeing. I aimed to answer the following research questions:

RQ1. What influences does urban nature have on the urban smellscape experience?

RQ1a. Which olfactory elements does urban nature bring into the perceived urban smellscape?

RQ1b. What influences does urban nature have on the interpretation of the perceived urban smellscape through associations?

RQ1c. What influences does urban nature have on the feelings evoked by the urban smellscape?

RQ2. To what extend does urban nature contribute to a preferred urban smellscape?

RQ2a. Which elements of the urban smellscape are perceived as pleasant?

RQ2b. What influences does urban nature have on the evaluation of the urban smellscape?

RQ3. To what extend does the olfactory experience of urban nature contribute to a landscape that fosters wellbeing?

8.1 Urban nature's influences on the perceived smellscape

Urban nature is clearly olfactorily perceived when present in the cityscape. These perceptions are triggered by diverse smells from nature as smellscape stimuli: decomposing leaves (typical for autumn), moist soil, plants, grass, flowers, water bodies and multiple specific plant species. Furthermore, urban nature could be olfactorily perceived as forest and/or natural processes.

Besides, urban nature influenced the perceived smellscape characteristics compared to grey smellscapes. Urban nature was perceived to have a strong, yet subtle smell – positively intense – whereas human induced smells such as smoke and exhaust gasses were often perceived as penetrant when strong.

The elements urban nature brings to the smellscape also occurred in areas with isolated green elements – in the SEMI locations. For example, just a few trees were sufficient to bring smells of nature saliently in the landscape and to evoke the olfactory perception of forest. However, these elements are perceived considerably stronger and more continuously in an urban park – GREEN locations. In GREEN locations, the smellscape is perceived as constantly present with a wide variety of smells of nature.

Associations with smells are highly individual, so it is hard to conclude that olfactory perception of urban nature evoked specific associations. Yet, general patterns are salient. The smells of nature evoke different associations than smells in grey areas. Many human-induced smells in GREY were associated with harmful effects people have on environmental quality or with cosiness of people's life; hence, evoking either a positive or negative affective response. Smells of nature were mostly associated with nature itself, being away from the city, healthiness, air quality, seasonality and forests. Furthermore, smells of nature evoked many autobiographical memories going back to childhood.

The feelings evoked are largely dependent on individual associations made. Yet, general patterns are again salient. Smells of nature in my study often evoked positive affective responses. Emotions that were mostly expressed in reaction to smells of nature were happiness, calmness, freedom and nostalgia – and overall a notion of pleasantness. Contrary to feelings evoked by human induced smells, which ranged anywhere from disgust to comfort.

Furthermore, the smellscape experience is linked to the breathing experience. Smellscape perceptions can be described in air quality related terms, such as cold, open and dense. As such, smellscape experience has association with healthiness and air quality. Smells associated with harmful substances can give the feeling of breathing impairments; while smells of fresh air and nature can give the feeling of a deeper and healthier breathing experience.

It is to note however, that the study's set-up increased the olfactory attention. Hence, despite urban nature showed to have the above described influences on the smellscape experience, this may not represent everyday smellscape experience per se.

To conclude and answer RQ1, urban nature has shown in this study to influence the smellscape experience by adding a great variety of smells and by changing the appearance of the smellscape. The changes urban nature brings to the smellscape are perceived through associations with nature itself (hinting to more-than-urban nature), health, environmental quality and individual memories. These associations generally evoke more positive affective responses than grey smellscapes. These effects occurred in cityscapes containing natural elements and to a larger extend in urban parks.

8.2 Urban nature's contribution to smellscape preference

Affective response expressed as a degree of pleasantness is a dominant dimension in smellscape experience. Several olfactory environmental qualities were positively correlated with olfactory pleasantness: freshness, naturalness, calmness, purity, liking and cleanliness. When urban nature was present, the smellscape scored higher on these qualities. Smells of nature were generally perceived as more pleasant the more intensely they were perceived. However, intensity only contributes to pleasantness when the smell was liked and the contrary goes for disliked smells. Familiarity and expectedness of smells did not correlate with pleasantness per se, but rather moderated negative judgement.

Furthermore, olfactory pleasantness appeared highly dependent on individual association and memories evoked by the smells. When associations were positive, the smell was also judged more pleasant; whereas negative associations substantiated negative judgements. Especially autobiographical memories induced very strong positive (and by exception negative) affective responses to smells. In my study, urban nature in the smellscape evoked relatively many positive associations and autobiographical memories. Based on that, participants generally evaluated smellscapes with more smells of nature more positively and pleasant.

Perception of healthiness and fresh air also played a dominant role in smellscape pleasantness. Olfactory perception were often linked to environment quality and healthiness, which tend to be more positive when elements of nature were present. In the urban smellscape without nature, the air was more referred to as musty, stinky or dusty; whereas smells of nature were associated with better air quality and freshness. As such, the olfactory perception of urban nature can contribute to perceiving higher environmental quality.

Smellscape preference results from smellscape experience and evaluation. In my study, two main reasons are found for smellscape preference: (1) the most positive affective responses, mostly in the form of pleasantness, freshness and calmness, and evoked by green elements in the cityscape; and (2) the experience of nature in the cityscape, which can be assumed to be caused partly by the olfactory perceptions.

To conclude and answer RQ2, urban nature increases the perceived pleasantness of smellscapes and smellscapes are evaluated higher when nature is present. Smells of urban nature are generally judged more positively, based on initial reactions and associations. Therefore, smellscapes with urban nature are preferred above smellscapes without urban nature and two main reasons are given. However, smellscape preference is highly subjective and influenced by individual associations and cultural constructs, thus it remains unknown whether part of this smellscape preference is innate. Furthermore, it remains unknown to what extend the smellscape pleasantness and preference is influenced by visual perception of urban nature.

8.3 Possible contributions to wellbeing

The smellscape experience of participants was influenced by other sensory impressions, mostly by visual perception of the cityscapes. Therefore, no hard evidence was found for a relation between olfactory perception of urban nature and contributions to wellbeing. However, after analysing the qualitative data, possible contributions of olfactory perception of urban nature can been formulated. As such, I bring forward several hypotheses for further research.

First of all, olfaction seems to provide information on environmental quality. Perceived environmental quality contributes to residential satisfaction and quality of life, therefore to wellbeing. Smelling nature was often associated with cleanliness and health, compared to the grey cityscapes, which induced positive affective responses. Whereas other smells, especially of cars, were associated with bad environmental quality, causing negative affective responses. Thus, the perception of a healthy and clean environment can be a possible pathway through which olfactorily perceiving urban nature contributes to an urban living environment promoting wellbeing.

Second, olfaction possibly enables direct and meaningful contact with nature. Smelling urban nature was associated with smelling forest and being way from the city, suggestively more so than visually perceiving urban nature since the visual landscape was dominated by buildings. Since contact with nature has proven to contribute to wellbeing, olfaction may be a sensory pathway through which this effect occurs. Furthermore, smelling nature can contribute to a perception of naturalness, therefore to restorativeness of the landscape. With certainty it can be said, based on my results, that smelling nature is part of multisensory contact with and experience of nature, since associations were made with the smells specifically. Further research is needed and encouraged to go in-depth on sensory contact with nature.

Third, smelling nature seems to evoke many positive affective responses and autobiographical memories from childhood. Both positive emotions and autobiographical memories are linked more to smell than the other senses. Both such feeling and memories contribute to wellbeing through upwards spiralling. Besides, the evocation of positive emotions can reduce stress. Thus, a third possible pathway through which olfactorily perceiving urban nature contributes to a living environment promoting wellbeing is by evocation of positive emotions and memories.

To conclude and answer RQ3, no direct influence of olfactory perception of green urban landscapes on wellbeing were found in this study. However, the results postulate three possibilities that can be used as hypotheses for further research, accentuating the explorative character of my research.

8.4 Final remarks

Humans are multisensory beings in essence. My results, above all, confirm this statement and indicate that landscape experience goes beyond vision. Olfactory

perceptions contribute to landscape experience through affective responses, associations, memories, the perception of environmental quality and the perception of urban nature. Furthermore, olfactory contact with nature seems to be part of the human-nature interactions in the cityscape.

My study provides new insights in the olfactory dimension of multisensory landscape experience that will hopefully contribute to unravelling the complexity of human landscape experience, human-nature interactions and their relation with wellbeing. Furthermore, my study opens a call for more in-depth and in-situ research to olfactory and multisensory landscape experiences across space and time, and I encourage researchers to do so, since many questions remain unanswered. For instance, which olfactory perceptions are induced in other seasons and places? How is smellscape experience influenced by culture? Which experiences are triggered when certain senses are excluded? What happens in the neural and neurological system when smelling nature? What is the exact role of smell in the multisensory landscape experience? And in nature connectedness?

If we truly want to understand how landscape and nature experience in the urban living environment is connected to wellbeing, a multisensory approach is appropriate. By understanding humans' multisensory landscape experience and preference, the city of the future can be designed to evoke happiness rather than depression, calmness rather than stress. It becomes increasingly clear, that nature is part of that city.

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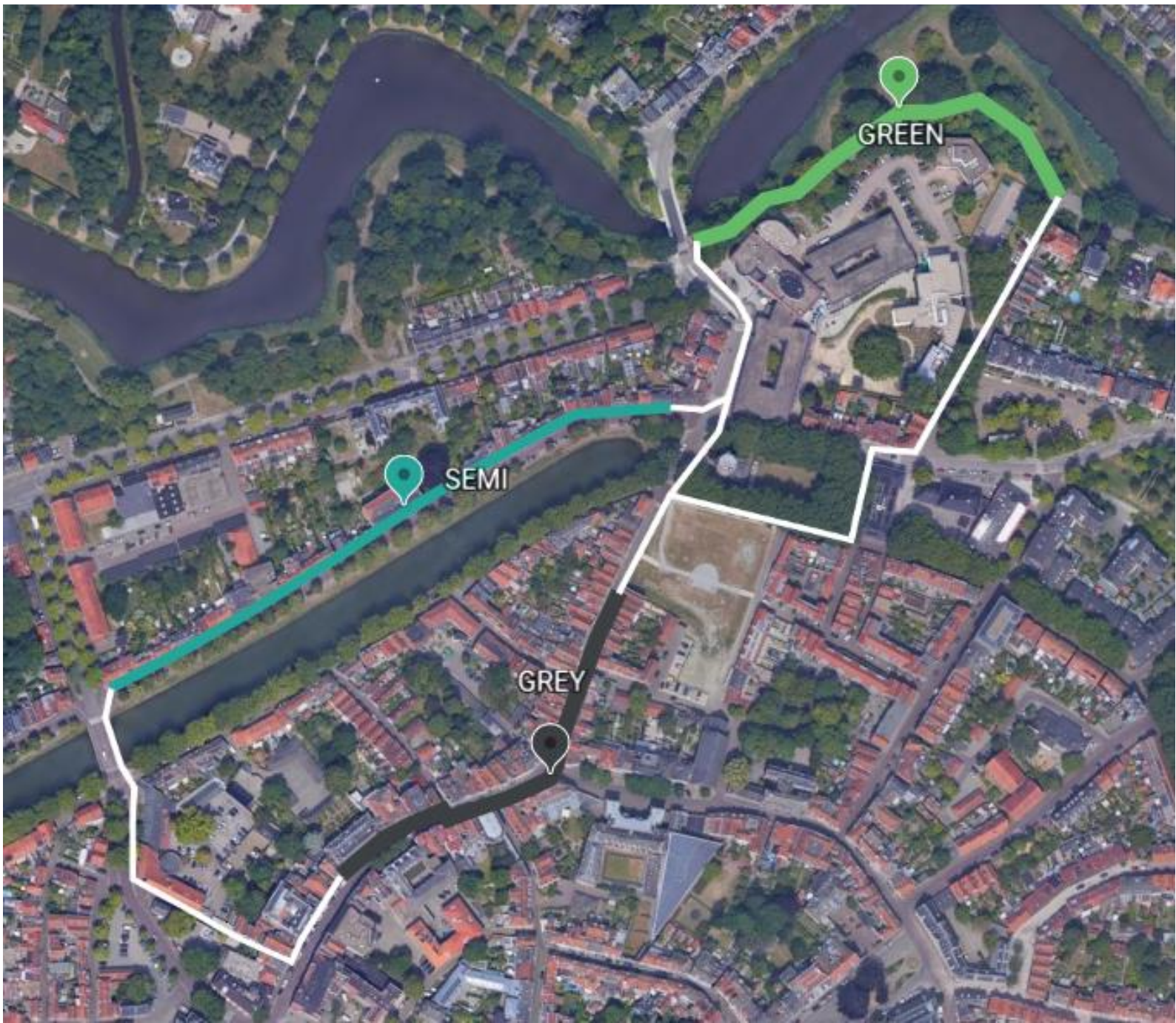
Appendix I: Routes and locations smellwalks

City: Middelburg

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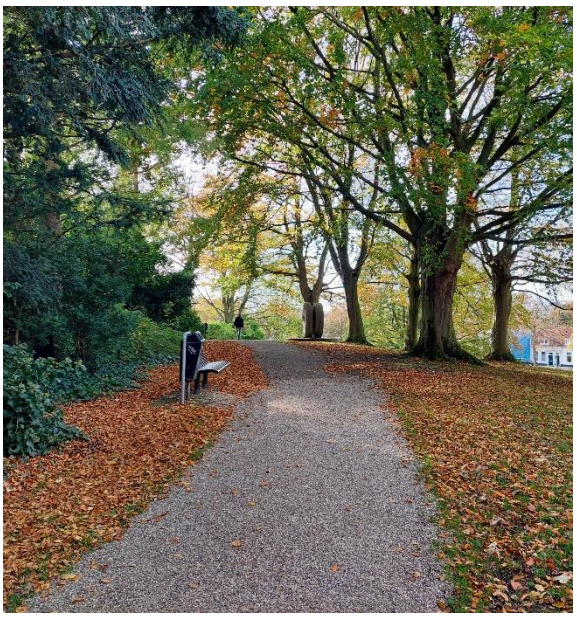
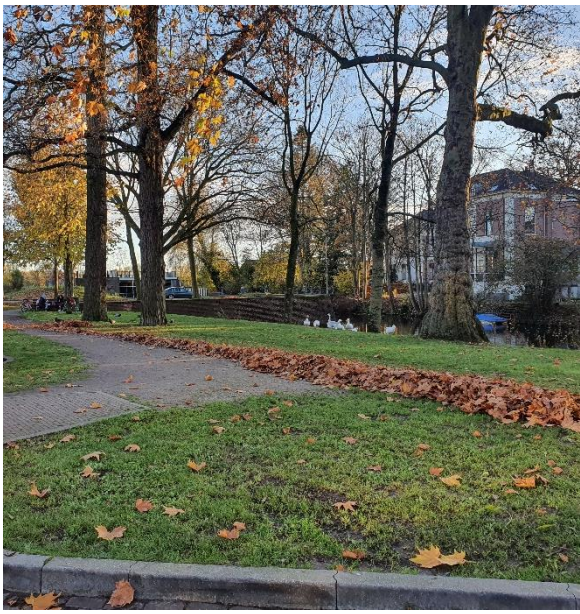
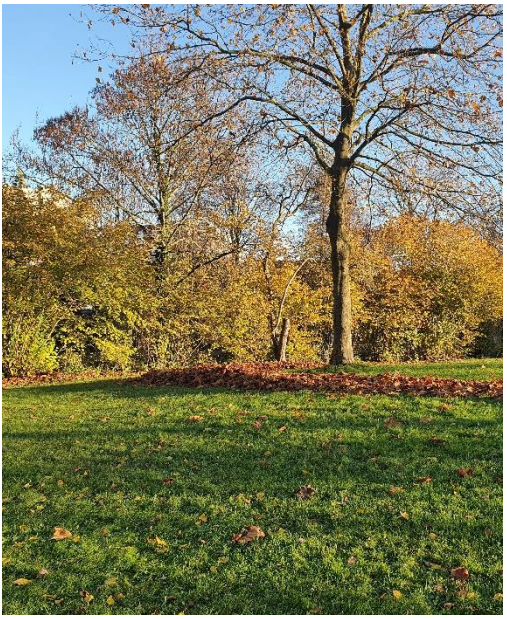
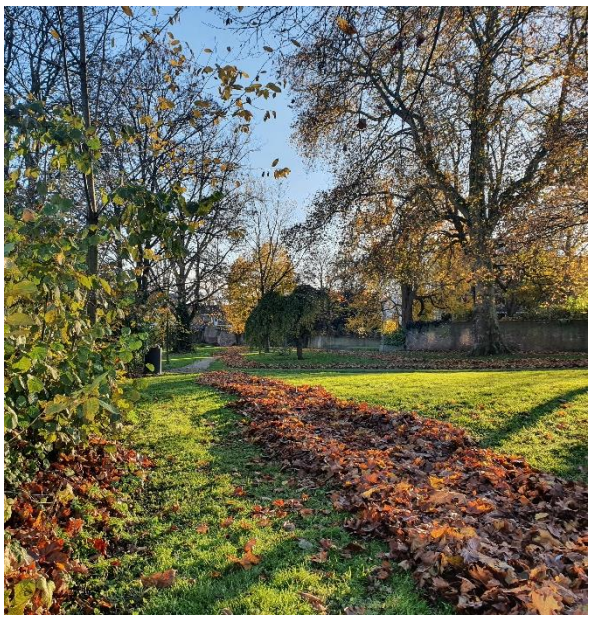


City: Wageningen

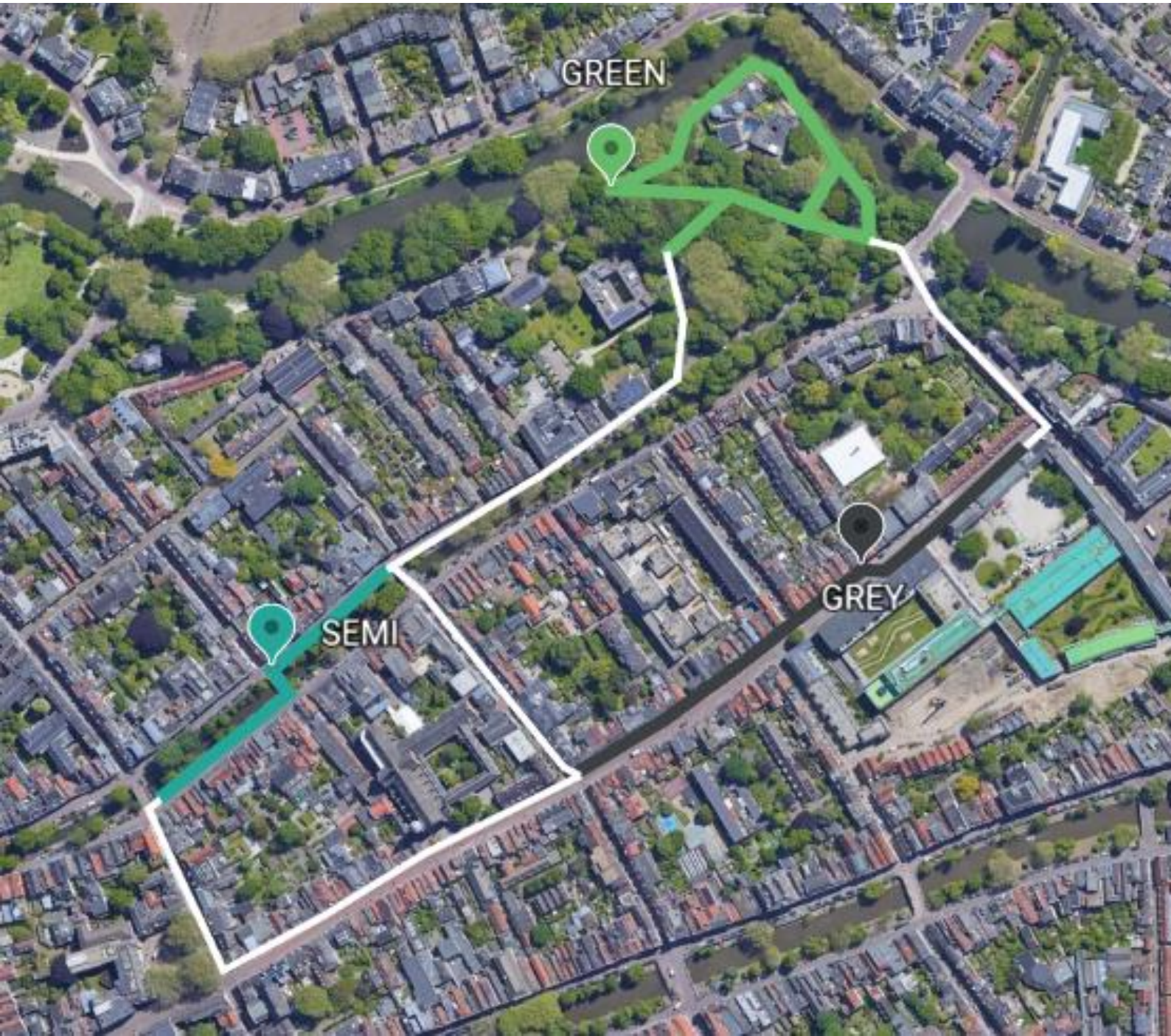

H41





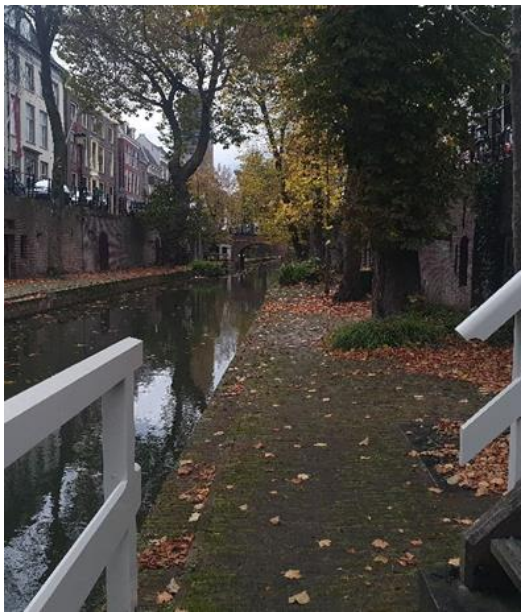
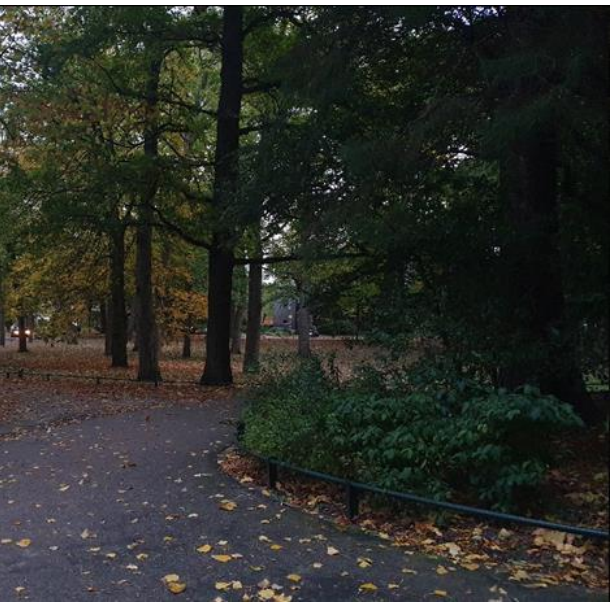


City: Utrecht







Appendix II: Data sheets for in the field

Date:_____

Time:_____

Code:_____

Person:_____

Geurwandeling in de Stad

Weersomstandigheden:_____

Persoonlijke informatie

1. Gender: [] Vrouw
   [] Man
   [] Anders
   [] Zeg ik liever niet

2. Leeftijd: _____

3. Welke opleidingsniveau(s) doe je of heb je gedaan?

   [] Middelbare school [] BSc
   [] MBO [] MSc
   [] HBO [] PhD

4. Rook je? [] Ja [] Nee [] Soms

5. Is je geurzintuig verminderd door een COVID-19 infectie, verkoudheid of iets anders?
   [] Ja, COVID-19
   [] Ja, verkoudheid
   [] Ja, anders
   [] Nee

6. Hoe stressvol is je dag tot nu toe?

1									10

Helemaal niet stressvol — heel erg stressvol

Date:_____

Time:_____

Code:_____

Person:_____

7. Hoe beoordeel je jouw actuele mentale welzijn?

[] Heel goed

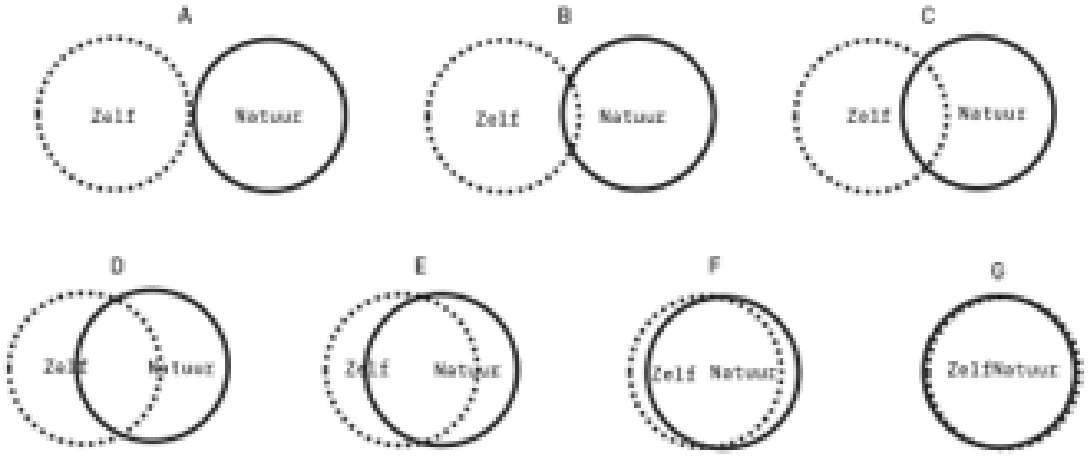
[] Goed

[] Gemiddeld

[] Onder gemiddeld

[] slecht

8. Hoe verbonden voel jij je met de natuur? Kies het figuur dat het best jouw relatie met de natuur weergeeft.



9. Over drie weken wil ik graag nog een vraag stellen. Wil je hier contactgegevens invullen via welke ik de vraag kan opsturen?

_____

_____

_____

10. Ben je geïnteresseerd om na afloop van het onderzoek een samenvatting van de resultaten te ontvangen?

[] Ja

[] Nee

Date:_____

Time:_____

Code:_____

Person:_____

Vragen Locatie 1/2/3

1. a. Hoe prettig beoordeel je de *visuele* omgeving hier?

[] erg onprettig [] onprettig [] neutraal [] prettig [] erg prettig

b. Hoe prettig beoordeel je de *olfactorische* omgeving hier?

[] erg onprettig [] onprettig [] neutraal [] prettig [] erg prettig

2. Beoordeel het geurlandschap op de volgende eigenschappen:

zwak	1									10	dominant
gemengd	1									10	puur
vies	1									10	schoon
muf	1									10	verfrissend
irritant	1									10	kalm
afkeer wekkend	1									10	fijn
onbekend	1									10	vertrouwd
onverwacht	1									10	zoals verwacht
kunstmatig	1									10	natuurlijk

3. Focus op de geuren in de omgeving. Hoe voel je je hier? Vul in of je het eens bent met de volgende stellingen.

	Eerder het tegenovergestelde	Nee	Een beetje	In zekere zin	Ja	Heel erg
Ik voel mij rustig						
Ik voel mij relaxed						
Ik voel mij energiek						
Hier kan ik het alledaagse even vergeten						
Mijn hoofd is helder hier						

Appendix III: Study-specific coding system, a step-by-step explanation

Step1: Reducing the text to information units per olfactory observation.

The text was divided in sections that concerned a distinct olfactory observation. Each time either a smell or the absence of smell was mentioned, being a separate observation from the previous one, that part of the text was given **a number** (see fig. IIIa). One observation unit could include multiple smells, for instance "I smell… nature, the leaves, the grass". Similarly, two olfactory observation over time could refer to the same constantly present smell (e.g. "I still smell those leaves"). Hence, the amount of olfactory observations does not equal the amount of different smells observed. Sometimes two observation were intertwined within the same part of the text, in that case the section was given two number. The text was divided in a total of **421 olfactory observations,** of which 157 in GREY, 134 in SEMI and 130 in GREEN.

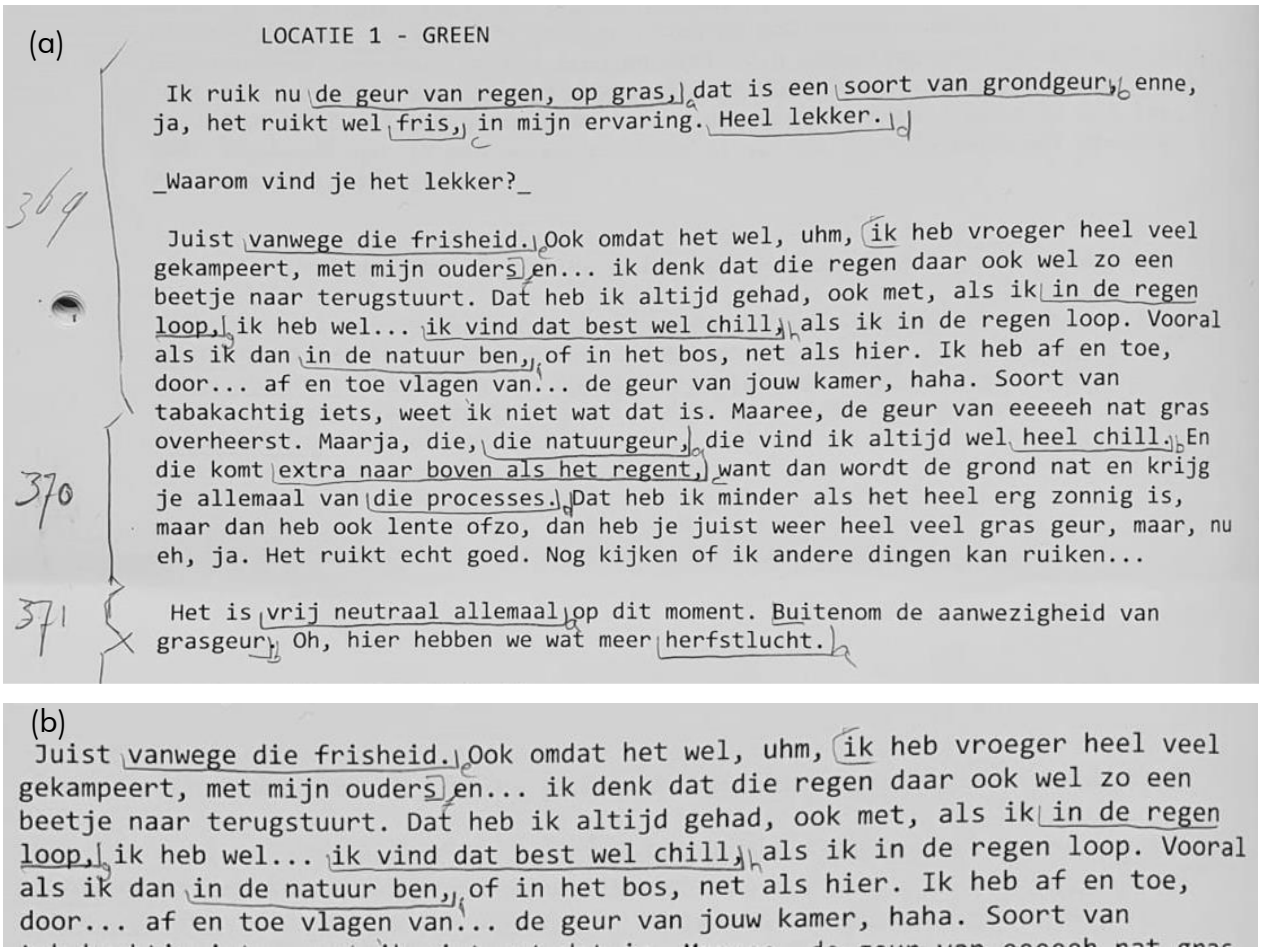
The text was reduced to information unit. A phrase or a sentence that contained information on the olfactory experience of the participant was labelled as an information unit. Each information unit was given **a letter** (see fig. IIIb). Within each olfactory observation, the lettering started over. Some olfactory observation had 18 to 20 information units, resulting in a maximum lettering range of **a-t.** The text was reduced to a total of **1918 information units, hence 1918 code lines, each labelled a number and letter** (see an example figure III).

For the two questions at the end of the smellwalk, the same reduction method was used. Only here every distinct answer was label **a number,** and every information unit within that answer **a letter**. This resulted in **51 answers** and a total of **171 information units.**

The information units form the basis of the coding system. Each information unit were assigned several codes in the first and second cycle of coding. The first cycle coding keeps close to the actual text, transforming the text in a list of codes. Whereas second cycle coding interprets the first cycle codes in broader categories.

Step 2: First cycle coding – process coding and in vivo coding

First cycle coding was performed using initial coding, which is an elemental method that builds a foundation for further coding (Saldaña, 2009, p.66). Initial coding in this study existed of two parts: a *process code* and either a *in vivo code* or a *summarised code*. The process code indicated what the participant was doing with language, see categories under. The *in vivo codes* are exact citations from the transcript that indicate the meaning expressed. When the information was expressed in a longer sentence, a *summarised code* was used. So, in the first cycle coding, all information units were given a process code and either an in vivo code or a summarised code (see table III).



(a)

LOCATIE 1 - GREEN

Ik ruik nu de geur van regen, op gras,a dat is een soort van grondgeur,b enne, ja, het ruikt wel fris,c in mijn ervaring. Heel lekker.d

369

Waarom vind je het lekker?

Juist vanwege die frisheid.e Ook omdat het wel, uhm, ik heb vroeger heel veel gekampeert, met mijn ouders en... ik denk dat die regen daar ook wel zo een beetje naar terugstuurt. Dat heb ik altijd gehad, ook met, als ik in de regen loop,f ik heb wel... ik vind dat best wel chill,g als ik in de regen loop. Vooral als ik dan in de natuur ben,h of in het bos, net als hier. Ik heb af en toe, door... af en toe vlagen van... de geur van jouw kamer, haha. Soort van tabakachtig iets, weet ik niet wat dat is. Maaree, de geur van eeeeeh nat gras overheerst. Maarja, die, die natuurgeur,a die vind ik altijd wel heel chill.b En die komt extra naar boven als het regent,c want dan wordt de grond nat en krijg je allemaal van die processes.d Dat heb ik minder als het heel erg zonnig is, maar dan heb ook lente ofzo, dan heb je juist weer heel veel gras geur, maar, nu eh, ja. Het ruikt echt goed. Nog kijken of ik andere dingen kan ruiken...

370

371

Het is vrij neutraal allemaal op dit moment. Buitenom de aanwezigheid van grasgeur,a Oh, hier hebben we wat meer herfstlucht.b

(b)

Juist vanwege die frisheid.e Ook omdat het wel, uhm, ik heb vroeger heel veel gekampeert, met mijn ouders en... ik denk dat die regen daar ook wel zo een beetje naar terugstuurt. Dat heb ik altijd gehad, ook met, als ik in de regen loop,f ik heb wel... ik vind dat best wel chill,g als ik in de regen loop. Vooral als ik dan in de natuur ben,h of in het bos, net als hier. Ik heb af en toe, door... af en toe vlagen van... de geur van jouw kamer, haha. Soort van

Figure III. A small part of the interview transcript of P_W4 to illustrate how the transcript is reduced to information units. (a) Each olfactory observation is labelled a number, here 369-371 are visible, and (b) each information unit within an olfactory observation is labelled a letter, here e-i are visible.

The following process codes were used in the first cycle coding:

- ***Describing:*** *the words assigned to the smell at the moment a participant notices the smell.* One olfactory observation can have two or more describing codes, for instance when "leaves and grass" is smelled. Sometimes the description does not correspond with the smell source, for instance, a participant can say they smell "nature", however, nature as such cannot be smelled, it refers to the combined smell of plants, soil, leaves and so on. Therefore, sometimes the boundary between *describing* and *associating* is rather vague.
- ***Judging:*** *the adjective given to the smell by the participant, such as nice, comfortable, terrible.* Therein also *fresh*, because this word was often used as a positive adjective. Almost all smells were judged by the participants, from the pilot study it appeared that judging implied the valuating and feelings one has to the smell – more so than directly asking which feelings where evoked. Participants found it difficult to point towards feelings or emotions, except in distinct cases, and rather expressed feelings/emotions through judgements and associations, or after asking *"why?"* a few times.

- ***Associating:*** *concept or objects thought of outside of the source of the smell.* Often indicated by phrases like: *"makes me think of…", "also smells a bit like…";* but not always.
- ***Feeling:*** *explicitly stated feeling, such as happiness, fear or comfort.* Some smells were only judged and associated, together implying feeling, but others were said to evoke an explicit feeling.
- ***Noticing:*** *when the participant noticed a certain characteristic of the overall smellscape or smells.* Mostly adjectives such as strong, weak, constant absent of smell; or a description such as "a mixed smell pallet".
- ***Experiencing:*** *inner experiences of participants, such as becoming calm or the difficulty with finding words.* These experiencing go deeper than just a feeling.
- ***Comparing:*** *when a participant compares the current location with one of the previous locations.*
- ***Preferring:*** *as answer to the final question, which location smellscape the participants does prefer.* Always GREEN, SEMI or GREY.
- ***Reasoning:*** *the reasons participants have for preferring a certain location's smellscape.*

Step 3: Second cycle coding – focussed coding

The second cycle coding system is based upon focussed coding, which is to develop salient categories within the data that are formed by clustering first cycle codes. Focussed coding already points to themes for a thematic analysis (Saldaña, 2009). Second cycle coding is this study existed of two parts: a second and a third layer code - each layer forming broader categories (see table III). Thus, each line of coding was assigned two layers of second cycle codes, based on the first cycle codes. Because the process codes divide all codes into categories that are useful to answer separate sub-RQs, these process codes remained the most important level of ordering.

The second layer codes exists of **597 different codes in total**, being clusters of 1 to 46 first cycle codes, of which around half only appeared once, for instance when it considers very specific personal associations; and other codes appear very often, such as the describing code "decomposing leaves". The first cycle codes were reduced as much as possible without losing essential information.

A third layer of coding has been assigned to all second layer codes, which further clusters the codes in even broader categories. In this layer of coding, all codes were placed in a broader category, as opposed to the second layer coding. This resulted in **82 different codes in total**, being clusters of 2 to 226 first cycle codes. The third layer of codes makes it convenient to have a broad overview of the data and the overall general patterns, but they compromise a lot of information. Therefore, the second instead of third layer codes were sometimes used for further in-depth analysis of the relations between process code categories.

Table III. An example of the coding process, translated from Dutch. Three information units (72f, 227a, 369b) are assigned a process code *and a* in vivo *or* summarised code *in the first cycle of coding. In the second cycle of coding, they are assigned a* 2nd layer code *and* third layer code.

participants	number	letter	process code	in vivo OR summarised code	in vivo?	2nd layer code	3rd layer code
P_M4	72	f	describing	smell of soil	YES	(moist) soil	smells of nature
P_U3	227	a	judging	does smell nice	YES	nice	POS
P_W4	369	b	noticing	suddenly something very strong	YES	locality smells	locality smells

Step 4: Pre-analysis of codes

The codes were analysed per location to be able to compare the three locations. For each code in the category *feeling, remembering, associating* and *experiencing,* it was analysed in relation to which smell source these feelings, memories, associations or experiences were mentioned. These relations between process codes and smell sources revealed patterns telling which smells evoked which feelings, memories, associations and experiences.

Judging codes were divided into five category in the last layer of coding. These categories being: very negative (NEG-), negative (NEG), neutral (NEU), positive (POS) and very positive (POS+). It was analysed which smell source evoked with judgement.

Dominant codes in the data, those that appeared frequently, were analysed separately. These included: autumn, nature, forest, cleanliness, fresh air, breathing and health. These categories were often mentioned in as associations or feelings. For each location, it was analysed which smells evoked these associations and feelings.

Noticing codes, or: the perception of the smellscape characteristics, were analysed on themselves. For each location, all *noticing* codes were taken together to describe the overall pattern of smellscape characteristic per location.

For the *comparing* and *preferring* codes, all codes from the thee locations were taken together to describing the overall pattern in how participants compared and preferred locations.

This step was highly complicated and required to go back and forth through the data set many times. Great caution was needed in order to keep an overview of which smell sources evoked the feelings, associations and so on. Sometimes it was useful to, for instance, colour certain codes (e.g. "POS", "health") to enable a faster scanning of the data, or divide the set to only display the process code/category at hand.

By analysing every code line in relation to the other code lines in the same olfactory observation, and by analysing these relationships in relation to the relationship of the other olfactory observations, meaningful patterns through the entire data set could be established.

Appendix III: Full set 3rd layer codes in Dutch

process code	3rd layer code	#tot	#grey	#semi	#green
associeren	natuurlijke processen / seizoensverandering	48	5	18	25
associeren	het herfstseizoen buiten	33	3	14	16
associeren	buiten zijn/in de natuur	30	2	10	18
associeren	mensenleven	28	18	7	3
associeren	meer dan park natuur	17	3	7	7
associeren	andere storende momenten	15	2	4	9
associeren	huiselijkheid van herfst	13	3	6	4
associeren	momenten in de natuur	13	0	3	10
associeren	de natuur	12	2	1	9
associeren	gerelateerd aan (bereiden van) eten	11	5	3	3
associeren	kindertijd	10	2	2	6
associeren	viezigheid	10	4	5	1
associeren	de stad	9	5	3	1
associeren	de stad (negatief)	8	7	1	0
associeren	gezondheid	8	1	2	5
associeren	articifieel	7	4	1	2
associeren	negatieve associaties	7	2	4	1
associeren	positieve associeties	6	3	2	1
associeren	verbonden met de natuur	6	0	2	4
associeren	warmte in herfst	5	2	1	2
associeren	negatieve ervaring honden	3	0	2	1
beleven	plaatselijk- en tijdelijkheid van geur	27	6	11	10
beleven	zwakkere geur	22	6	8	8
beleven	constante geur	20	5	7	8
beleven	sterkere geur	19	1	3	15
beleven	variatie in geur	16	4	2	10
beleven	penetrantie van articifiele geuren	14	9	1	4
beleven	wisselende sterkte geur	9	1	3	5
beleven	directe natuurgeur bij groenelement	7	2	3	2
beleven	sterkte van natuurgeuren	7	0	4	3
beleven	gewassen lucht door regen	5	1	2	2
beleven	constante afwezigheid geur	3	3	0	0
beschrijven	natuurgeuren	226	14	87	125
beschrijven	geuren van menselijke objecten	97	59	26	12
beschrijven	geurloosheid	59	31	22	6
beschrijven	geur vd lucht	45	17	14	14
beschrijven	uitlaatgassen en rook	43	26	14	3
beschrijven	stadsgeuren	42	30	8	4
beschrijven	dierlijke geuren	15	2	5	8
beschrijven	geur van afval	15	11	4	0
beschrijven	ondefinieerbaar	13	5	3	5
beschrijven	gemengd pallet	12	4	6	2
beschrijven	schoon	5	0	2	3

beschrijven	muffige geur	3	0	1	2
ervaren	geur en adem sterk verbonden	47	20	20	7
ervaren	multizintuigelijke ervaring	34	10	7	17
ervaren	moeite met verwoorden	24	6	10	8
ervaren	ongezondheid	22	16	5	1
ervaren	waarde natuur/mens	19	5	10	4
ervaren	weg zijn van stad/in natuur zijn	17	0	8	9
ervaren	verfrissende of kalmerende ervaring	15	5	5	5
ervaren	eerdere associaties bepalend	11	1	3	7
ervaren	verklaren met visueel	11	6	3	2
ervaren	bewuster dan normaal	7	2	3	2
ervaren	etensgeuren wekken honger op	5	5	0	0
ervaren	geur ondersteund gevoel	5	1	1	3
ervaren	moeite beschrijven oordeel geur	5	1	3	1
ervaren	verwachtingen	5	1	1	3
ervaren	seizoensverandering invloed op gesteldheid	4	1	2	1
ervaren	imiginaire geur gesuggereerd	3	2	0	1
ervaren	penetrantie artificiele geuren	3	0	2	1
ervaren	post-covid vergelijking	3	0	3	0
herinneren	positieve herinneringen uit kindertijd	49	11	14	24
herinneren	positieve herinneringen uit recent leven	14	6	6	2
herinneren	negatieve herinneringen uit kindertijd	2	0	1	1
oordelen	POS	148	27	62	59
oordelen	NEG	116	62	30	24
oordelen	NEU	53	24	9	20
oordelen	POS+	38	7	12	19
oordelen	NEU: gewenning/het hoort maakt oke	20	12	3	5
oordelen	POS: waarde natuur/mens	14	2	7	5
oordelen	NEG-	11	5	3	3
vergelijken	natuur in locatie bevorderd geurervaring	32	7	13	12
vergelijken	duidelijk verschil tussen grijs en groen	28	4	18	6
vergelijken	vergelijkbare elementen green en semi	6	0	5	1
voelen	positieve gevoelens	44	9	13	22
voelen	negatieve gevoelens	29	13	12	4
voelen	rustig worden	16	0	5	11
voelen	instinctieve reactie	13	6	3	4
voelen	gevoel gerelateerd aan natuur	12	1	0	11
voelen	neutrale gevoelens	8	3	3	2
voelen	gemengde gevoelens	2	0	1	1

Appendix IV: Popular science article

Future cities smell healthy and green

Designing the future city should include the olfactory dimension as well, recent research suggests. Next to the visual aesthetics and noise (annoyance), also smells in the urban environment have influence the wellbeing of residents.

Interactions with urban nature are increasingly considered as an undisputed remedy against stress and impaired mental wellbeing caused by the grey urban environment. However, until recently studies focussed almost solely on visual interactions with nature, letting the mechanisms that are accountable for nature's contribution to wellbeing largely undiscovered. A novel study revealed that smells of nature trigger positive emotional responses in people walking through urban areas, suggesting olfactory interactions with nature to be a pathway that connects nature with wellbeing.

Moist soil after a summer rain, decomposing leaves in the cool autumn afternoon, the brisk smell of spring, flower beds sweet and intense, forest smell when getting out of the train after visiting a city. Undoubtedly familiar smells that trigger positive feelings. The sense of smells is known to trigger strong emotions and autobiographical memories directly, more so than other senses. The tone of which depend highly on associations made with the smells.

The study showed that smells of nature evoke positive feelings induced by among others childhood memories, associations with pleasant experiences, the perception of a healthy environment and the feeling of being able to breath deeply. On the other hand, human-induced smells in the city not rarely were associated with harmful effects on the environment and human life – except for the smells of food and perfume. Showing that humans partly interpret the environment through associative information from olfactory stimuli.

Human are multisensory beings in essence. By understanding and applying the role of smell in people's everyday environmental experience, a multisensory city design can foster wellbeing rather than stress by changing the associations and feelings people have while walking through their home environment. Urban nature has an important role in this multisensory city design, both visually and olfactory. Where public transport replaces combustion engines and waste management goes underground, plants can increase the beauty of urban environments. Plants can also fill the air with smells that enable citizens to interact with nature through their nose, resulting in pleasant environmental experiences.

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