Landscape and Urban Planning 94 (2010) 264–275

Contents lists available at ScienceDirect

Landscape and Urban Planning

journal homepage: www.elsevier.com/locate/landurbplan

The relation between perceived sensory dimensions of urban green space and stress restoration

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ARTICLE INFO

Article history:
Received 24 April 2009
Received in revised form 13 October 2009
Accepted 27 October 2009
Available online 26 November 2009

Keywords:
Preference
Health promotion
Public health
City planning
Characteristics

ABSTRACT

Research indicates a relationship between sensory perception of natural environments and human health. Our hypothesis is that people perceive green spaces in terms of certain dimensions, where some dimensions are more important and preferred than others with respect to restoring people from stress.

The aims are to: identify and describe the perceived dimensions in nature; identify which dimensions people in general prefer; identify the dimensions people reporting stress prefer; and identify a combination of the dimensions people reporting stress prefer.

A total of 953 randomly selected informants from nine Swedish cities (representative of the Swedish population) answered a postal questionnaire with pre-coded questions. The questionnaire consisted of three parts: personal data, preferences for natural qualities and self-estimations of health status. The data were analyzed using factor analysis and regression analyses.

The results identify and describe eight perceived sensory dimensions. People in general prefer the dimension Serene, followed by Space, Nature, Rich in Species, Refuge, Culture, Prospect and Social. The dimensions Refuge and Nature are most strongly correlated with stress, indicating a need to find the most restorative environments. A combination of Refuge, Nature and Rich in Species, and a low or no presence of Social, could be interpreted as the most restorative environment for stressed individuals.

From a city planning perspective, the results indicate how urban green spaces can be viewed as elements of importance to public mental health. However, before the dimensions can be used by practitioners as tools to promote health through city planning, more research is needed.

1. Introduction

During the past three decades, more and more research findings have pointed to urban green spaces as a resource in promoting public health. It has been suggested that green spaces promote health by restoring mental fatigue (Kaplan, 2001), serving as a resource for physical activities (Björk et al., 2008), and reducing all-cause and cause-specific mortality (Mitchell and Popham, 2008). However, most studies have concerned the resources that reduce stress levels (e.g., Grahn and Stigsdotter, 2003; Nielsen and Hansen, 2007; Ulrich, 2006). Most research studies have compared urban environments that have some kind of nature qualities with urban environments that have no nature qualities at all (e.g., van den Berg et al., 2002; Hartig et al., 2003; Velarde et al., 2007). From these studies we learn that access to nature in urban environments is better than no access to nature. Thus, we learn very little about the qualities found in the urban green environments.

We live in an urbanized world. About 75% of inhabitants in the developed countries live in dense urban areas (Habitat, 2001). In the present debate on the dense city contra the sprawled city, the dense city is often considered a suitable direction for future city planning, the idea being that such cities promote sustainable development (Hardy, 2004). There is a need to understand and analyze the qualities found in urban green spaces if we are to make sound decisions about which green spaces have potential to be developed into restorative environments (Velarde et al., 2007). Which qualities in green spaces are popular among and important to inhabitants and which are not so important? In order to understand this, we need to improve our knowledge and understanding of how people experience and perceive urban green spaces.

1.1. Perceiving urban green spaces

Perception is described as the process of attaining awareness and understanding of sensory information (Bell, 1999). This information is registered by a variety of sensory cells, and passed on

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doi:10.1016/j.landurbplan.2009.10.012

to the sensory organs or senses. It is not easy to define how many senses we have, or even to define what a sense is. Some claim there are five senses, others say twelve (Ayres, 1983), and still others count even more. Tactile sensations and touch involve many sensory cells, such as those registering temperature, humidity, soft touch, pressure, the feeling of texture, etc. Our body movements give us information about speed and direction, elevation and the resistance our bodies meet when moving about (Ayres, 1983; Bell, 1999). Some senses can be defined as distance senses (vision, hearing and, to some extent, smell), while the other senses are nearness senses (Bell, 1999). However, we rarely use senses in isolation; on the contrary, they most often work in concert (Bundy et al., 2002). The brain interprets the information from all our senses together with our memories of earlier episodes, which gives us a full experience and understanding of our environment (Bell, 1999; Bundy et al., 2002).

1.2. Sensations, health and well-being

Vision is a sense of utmost importance when visiting urban green spaces. However, other senses are also of great importance, not least concerning the connection between use of urban green spaces and people's health and well-being. In her program designed to treat and rehabilitate handicapped children, Ayres (1983) found that information from tactile sensations appears to be basic to the individual's sensory integration, leading to cognitive and sensory–motor development. Moreover, research results indicate that information derived from our senses is coded and stored through three different processes: subsymbolic, symbolic imagery, and symbolic verbal (Bucci, 2003). Subsymbolic processing operates in the sensory, motor, and somatic modalities. It helps the soccer player understand how to handle the ball in the field, and the wine taster judge the quality of a wine. These knowledge processes occur in specific sensory-somatic modalities rather than in systematic cognitive ways: Information is processed via our muscles, inner organs, etc. (Bucci, 2003). In contrast to subsymbolic processing, symbols may be images (e.g., a visual picture in a person's mind) or words (e.g., verbal concepts and interpretations; Bucci, 2003).

These three systems have different contents and different principles of organizing and storing information in our body and brain. However, they are connected by referential links, with the help of symbolic images, which enable us to symbolize and verbalize our emotional experience and also to understand others (Bucci, 2003). Sometimes the three systems have a harder time connecting—for instance, when people are feeling poorly. Here, sensations and images from the environment can work as a catalyst, mediating information between the three systems, which is of utmost importance to mental restoration (Bucci, 2003). Searles (1960) also pointed out that signals from nature act as a catalyst, sparking creative processes that are important to restoration. Complicated relations may be too much to handle. Most complex are our relations to other people, and the simplest relations are those between inanimate objects, such as stones, and us. Plants and animals fall somewhere in between. According to Searles, being able to master these relationships helps us to recover from crises (Ottosson and Grahn, 2008; Searles, 1960). According to these theories, urban green spaces rich in sensations with no or low demands, which are processed subsymbolically as well as through processing at the symbolic imagery and symbolic verbal levels, may offer possibilities for restoring people's health and well-being.

If we are to perceive and act appropriately and quickly in the environment, we cannot pay attention to all information coming from our senses. To avoid chaos when making decisions in relation to everyday rapid activities, we need to find order and hierarchies. One of the theories of how we discern order from the perceived cues presented to us is called Gestalt theory (Perls et al., 1970; Bell, 1999), which proposes that separate figures of wholeness (Gestalts) stand out from the rest of the environment. Ehrenzweig (2000) defined this conscious, rapid type of perception using Gestalts as "surface perception". According to Ehrenzweig (2000), sensory information can also be perceived and stored unconsciously in the form of more undifferentiated information, that is, not Gestalts. He defined this type of perception as "depth perception". Depth perception is needed to get a sense of the "true world", and it is normally fluently integrated with surface perception. However, Ehrenzweig also claimed that dissociation between depth perception and surface perception (caused by, e.g., stress) could cause mental illness. This dissociation can be broken if we have the opportunity and time to make contact with depth perception—through unconscious scanning. Successful symbol formation depends on a fusion between the inner and outer worlds. Hence, our unconscious depth perception can provide us with symbols, helping us to restore and deepen our sense of reality by helping us find a hidden order in reality (Ehrenzweig, 2000). Although Bucci (2003) did not talk about depth perception, this is in line with her findings, showing that symbolic images mediate health processes as a referential link between information coded and stored through subsymbolic, symbolic imagery and symbolic verbal processes when the systems are dissociated.

1.3. Order and hierarchies

Gestalt theory has been used as a basis for claiming that people find order and hierarchies in the surrounding environment (Bell, 1999). Another theory is related to the ecological approach to perception, which suggests that we inherently and through conditioning look for certain cues or characteristics in our environment that afford us utilities (Gibson, 1979), where pleasure and beauty also constitute a kind of utility that offers us happiness. One example is that humans have always been forced to find shelter from the weather, dangerous animals and enemies. Given this need, we have learned to detect what characteristics of the landscape can afford us shelter and hiding places. Moreover, Stern (1985, 1993) claimed that, even as small infants, we perceive, understand and evaluate the environment by using our cognition and emotions simultaneously, so-called "vitality affects", which constitute a pre-linguistic language. Parents and infants use this language to communicate starting from the infant's first day of life outside the womb. In this way, characteristics in the environment are immediately given a cognitive and emotional label.

Based on the above, we could say that people interpret the environment in relation to certain classes, where some are more important than others, in that they are varyingly good or bad (Bell, 1999). These classes can be expressed as Gestalts or affordances, which we look for inherently or through conditioning. Moreover, we need peaceful, more undifferentiated areas where we have a chance to make contact with our basic senses and more deeply stored subsymbolic information. Preference is a concept that assumes a real or imagined "choice" between alternatives and the possibility of rank ordering these alternatives. The choice is based on the happiness, satisfaction, gratification, enjoyment and utility they provide. More generally, it can also be seen as a source of motivation (Stanford Encyclopedia on Philosophy, 2008).

This means that we cannot isolate perception of urban green spaces to vision, especially when we talk about well-being and health. When we are seeking information about the connections between experienced characteristics in urban green spaces and health, we must see perception as involving all our senses. But is it possible to make the general assumption that people prefer certain experienced qualities – including scents, touch and sounds – more than others, and especially when they are feeling poorly? In

order to test that idea, we need a way of dividing the experienced qualities of urban green spaces into certain classes.

1.4. Classification of perceived sensory environmental information

In the 1960s, planners tried to develop techniques for evaluating green environments in the countryside. Most often they used expert judgments (Clark, 1968), and criteria such as shape, color, scale and texture were often used. These routines live on, and evaluations of landscapes are still connected to obvious, measurable criteria, such as size, topography, distance and color (Gyllin and Grahn, 2005). However, such evaluations were also criticized early on for the more or less arbitrary variables being judged—a user perspective was considered necessary (Penning-Rowsell, 1973). A group of researchers began using preference studies, most often by showing photo-slides, in order to establish a foundation for evaluations of green spaces (Shafer et al., 1969). Since then, photo-based studies have been the predominant method in preference studies on large-scale landscapes in the countryside and in urban environments (Gyllin and Grahn, 2005). Considerably fewer studies have taken into account senses other than vision (Gyllin and Grahn, 2005).

However, Feste and Oterholm (1973) and Oraug et al. (1974) found that people's experiences of landscape dimensions include values such as wildness and culture, which is connected to, e.g., history. And Appleton (1975) proposed that people have inherent reflexes causing them to seek optimal places in the landscape, which have been important for human survival during our prehistory. More recently, several studies have found that experienced qualities in green spaces can be divided into certain characteristics: most often six to nine (e.g., Grahn, 1991; Grahn and Sorte, 1985; Kyttä and Kahila, 2005; Maikov et al., 2008; Ståhle, 2005; Tyrväinen et al., 2007; van Herzele and Wiedemann, 2003). These results show that people's reasons for going out into a landscape are rarely connected to the color or shape of the recreational site. On the contrary, visitors seek out experiences that they associate with nature and urban parks. It is likely that the perception of landscapes involves inherent reflexes as well as experiences connected to expectations of, e.g., finding different species or signs of history and culture. The most important finding from these studies is that visitors can identify all characteristics rather clearly and strongly in some green spaces, while other spaces may both lack many characteristics totally and show only weak signs of the remaining characteristics.

The above-mentioned studies have been carried out in different ways, concerning establishing the different characteristics: The study by Grahn and Sorte (1985) employed a postal questionnaire sent to every registered organization in nine Swedish cities. The study by Grahn (1991) was further developed in Berggren-Bärring and Grahn (1995) and took a triangular approach, consisting of a postal questionnaire sent to a random sample of organizations in three cities and qualitative methods directed at a strategic sample of these organizations. In addition to the questionnaire study, they used a combination of focus group technique and deep interviews. The questionnaires were processed in GIS. Grahn et al. (2005) made deeper analyses of the data collected by Grahn and Sorte (1985) and by Berggren-Bärring and Grahn (1995), now with a special emphasis on organizations within care and rehabilitation. Ståhle (2005) used a triangular design similar to that of Berggren-Bärring and Grahn (1995), however targeting individuals in Stockholm. Kyttä and Kahila (2005) used a web-questionnaire directed at individuals in a Finnish city, and the answers were processed in GIS. The study by van Herzele and Wiedemann (2003) was further developed in van Herzele (2005), and synthesized an extensive literature survey. Tyrväinen et al. (2007) and Maikov et al. (2008) synthesized a literature survey as well. All of the above studies focused on urban contexts. Stockholms Regionplane-och trafikkontor (2001) took a qualitative approach, using diary entries and deep interviews in a strategic sample of single persons living in Stockholm. Caspersen and Olafsson (2006) also synthesized an extensive literature survey. These two studies focused on more rural contexts.

1.5. Relationship between stress restoration and green spaces

Stress-induced illnesses have become a huge global problem. According to the World Health Organization (WHO), mental health disorders and cardiovascular diseases are expected to be the two major contributors to illnesses in all parts of the world, with mental health disorders calculated for all age groups and both sexes, by the year 2020 (WHO, 2008). Prolonged stress has serious and harmful effects on all vital organs, including the heart and blood vessels. During stress, our body organs react in many different ways, and if stress is sustained for an inappropriately long time without the possibility of recovery, these reactions become dysfunctional and harmful with the risk of causing deleterious changes to, for instance, the cardiovascular system and the neuro-hormonal systems of the body and of causing type II diabetes, depression and infections (Aldwin, 2007; Tsigos and Chrousos, 2002). In particular, many psychiatric diseases are strongly associated with prolonged and incorrect stress reactions, including schizophrenia, anxiety syndrome and, foremost, depression, exhaustion syndrome and fatigue syndromes (Aldwin, 2007; Tsigos and Chrousos, 2002). Hence, if people cannot find restoration from stress, their health will be affected in many ways. WHO has rated physical inactivity and stress as two of the major causes of death in the developed world, and consequently has made stress-related diseases and overweight priority health prevention areas (WHO, 2006, 2008).

Stress is not an illness per se, rather stress reactions are natural and necessary. They are fundamentally the same reactions that helped our early ancestors survive. In the event of a perceived threat, stress reactions trigger the fight-or-flight reflexes that serve to sharpen our senses. This is expressed physically through, among other things, increased attention, increased muscle tension, increased blood pressure, reduced digestive system activity, increased sweat gland production, increased pulse and increased production of adrenaline as well as hydrocortisone (Atkinson et al., 1996). For early humankind, who lived on nature's terms, the body's own adaptation mechanisms were suited to their purpose. In today's urban communities, we seldom need to fight or flee. We experience stress instead.

As mentioned earlier, research has shown a relationship between perception of the surrounding environment through our senses and human health (Ayres, 1983; Bucci, 2003; Kaplan, 2001; Ulrich, 1999). Today most research results' converge, indicating a positive connection between how often or how long people stay in urban parks or nature areas and restoration from stress and mental fatigue (e.g., Kaplan and Kaplan, 2005; Nielsen and Hansen, 2007; Mitchell and Popham, 2008).

1.6. Hypotheses and aims

Our hypotheses can be summarized in the following two statements:

First: People perceive green spaces in terms of certain dimensions.
Second: Some dimensions are more important than others as regards restoring people from stress.

The aims of the present study are to:

1. identify and describe perceived dimensions in green urban spaces;

2. identify the perceived dimensions people in general prefer;
3. identify the perceived dimensions people reporting stress prefer;
4. identify a combination of the perceived dimensions people reporting stress prefer.

2. Methods and materials

Our ambition here has been to focus on town-dwellers' everyday situation. Our goals were to obtain information on town-dwellers': background, in terms of sex, age and socio-economic status; habits of visiting urban green spaces; preferences for certain qualities in urban open green spaces; prevalence of symptoms of stress, and to determine whether there are any statistical relationships between the above-mentioned factors.

A quantitative survey in the form of a postal questionnaire with pre-coded questions was conducted. The aim was to obtain a representative picture of the situation of Swedish town-dwellers. Consequently, nine towns and cities were selected from the geographical areas in which most Swedish people live: close to Stockholm, Gothenburg and Malmö. Approximately 70% of the Swedish population lives in the above-mentioned areas (Statistics Sweden, 2009).

The questionnaire consisted of three parts. The first part asked questions about the respondents' personal data, like age, sex, and profession. The second part focused on preferences for certain qualities in the urban green spaces. In this part, we did not include any activities at all, and took pains to avoid more general words, like 'beautiful'. In the third part the respondents made self-estimations of their health status. All questions in the questionnaire were pre-coded, most often with multiple-choice options, however with an opportunity to make individual remarks.

To obtain a picture of the respondents' health status, the questionnaire included questions about the number of occasions per year each individual is afflicted by stress-related complaints. As regards stress-triggered reactions, several different tests (e.g., Maslach, 2001; Nyström and Nyström, 1995) are based on knowledge of clear symptoms of stress-triggered illnesses. An important test in this context is SCI-93, which was designed by two physicians, Nyström and Nyström (1995). It contains three modules concerning complaints due to stress, where one module deals with mental complaints, another with muscular complaints and a third with autonomous complaints. We chose seven questions focused on fatigue, headache, neck ache, backache, irritation, a feeling of being chased and stressed, and the common cold (viral infection). The answers were listed on an eight-step scale from "No, not at all" to "Yes, practically every day".

The association between different complaints was examined using factor analysis (SAS Varimax, orthogonal rotation). One distinguishable factor was formed by *stress*, *irritation* and *fatigue*. These three complaints all have values over 0.5 (Stress 0.64, Irritation 0.58 and Fatigue 0.58) and point to a strong factor that we have interpreted as a stress level (Grahn and Stigsdotter, 2003). This relationship is supported by the work of other researchers, who have described how a general feeling of stress is followed by fatigue, which in turn is followed by irritation (Kaplan, 1990; Währborg, 2002). Based on the variables stress, irritation and fatigue, a new variable was constructed, called 'Level of Stress' (LS). To ensure that the three different variables were weighted fairly in the new variable, the values were multiplied by the principal component value, PCA according to the formula: (PC stress × *stress*) + (PC irritation × *irritation*) + (PC fatigue × *fatigue*) = LS (Manly, 1994; Morrison, 1976). This health index has been presented earlier (Grahn and Stigsdotter, 2003; Stigsdotter, 2005).

The questionnaire was sent by mail to individuals of all ages who were selected at random. Infodata, which keeps the Swedish personal and address register, randomized the respondents' addresses. In total, 2200 questionnaires were sent out and 163 letters were returned to sender, which means that 2027 questionnaires were delivered successfully. A total of 953 completed or nearly completed questionnaires were returned; the response rate was thus 47% 733 respondents were adults.

The adult respondents' answers have been statistically analyzed using the statistical software SAS (SAS Statistics, 2002). Examination of the respondents' profile showed that the distribution of socio-demographic data is representative of the general situation in Sweden. This means that no statistically significant deviation existed with regard to socio-economic grouping (SES), sex or age between the received material and the material one could expect (Grahn and Stigsdotter, 2003; Statistics Sweden, 2009; Swedish Socioeconomic Classification Reports on Statistical Co-ordination, 1995).

3. Results

3.1. Factor analysis of preferred qualities

Using SAS factor analysis (SAS Statistics, 2002), we examined the association between preferences for the different qualities perceived in urban green spaces (data presented in Appendix A). Kaiser's Measure of Sampling Adequacy (Cerny and Kaiser, 1977) yielded 0.92, indicating that the applicability of factor analysis in our sample was high. The outcome indicates eight clearly distinguishable factors with eigenvalues > 1. The first factor has 41% of the total eigenvalues, the second 22%. The following six factors all have about 6% of the total eigenvalues. This indicates that the first factor is the clearest, followed by the second factor, and that the other six factors are more or less equally evident. The factors were then rotated, Promax oblique rotation, and are presented individually below.

3.2. Description of the single factors

Factor 1. In this first factor, we find that 'The urban park or urban open space has a nature quality' is the variable with the highest factor loading, followed by 'The urban park or urban open space has a wild and untouched quality' and 'There are free growing lawns'. This factor can be interpreted as comprising an experience of the inherent force and power of nature, its dynamic and intrinsic vitality. The experience includes a feeling of being in nature on its own conditions, which can be manifested among visitors in relaxing outdoor activities, such as lighting a fire. This relaxing atmosphere makes the visitor feel safe. All these variables point towards a *Nature* dimension of the green space (Table 1).

Table 1
Factor analysis, SAS Promax oblique rotation. Factor 1. All variables, qualities in urban green open spaces, related to Factor 1, loadings < ±0.30 not shown.

Variables	Factor loading
The urban park or urban open space has a nature quality	0.71
The urban park or urban open space has a wild and untouched quality	0.63
There are free growing lawns	0.54
It is possible to light a fire in the urban park or urban open space	0.50
It feels safe spending time in the urban park or urban open space	0.49
One is able to spend time in the urban park or urban open space without coming into contact with too many people	0.47
The urban park or urban open space contains hilly areas	0.44

Table 2
Factor analysis, SAS Promax oblique rotation. Factor 2. All variables, qualities in urban green open spaces, related to Factor 2, loadings < ±0.30 not shown.

Variables	Factor loading
The urban park or urban open space is decorated with fountains	0.73
The urban park or urban open space is decorated with statues	0.65
The urban park or urban open space contains a wide range of foreign plants, ornamental plants and kitchen plants	0.65
The urban park or urban open space has the characteristic of a city park	0.57
The urban park or urban open space has different water features, like ponds, canals, etc.	0.52
The urban park or urban open space is ornamented with flowers	0.50
The urban park or urban open space has a wooded pasture quality	0.46

Table 3
Factor analysis, SAS Promax oblique rotation. Factor 3. All variables, qualities in urban green open spaces, related to Factor 3, loadings < ±0.30 not shown.

Variables	Factor loading
The urban park or urban open space contains plane and well-cut grass surfaces	0.87
It is possible to have a prospect, vistas over the surroundings	0.78
The lawns are cut	0.76
The park or urban open space has soccer fields on grass	0.68
The urban park or urban open space has soccer fields on gravel	0.50
The soccer fields are lit up	0.48
That the urban park or urban open space has small ball grounds on asphalt	0.47
There are showers and changing rooms available	0.43

Factor 2. All variables in this factor contain elements of human artifacts: Fountains, statues, exotic plants, ponds, etc. The green space can be interpreted as decorated, as containing a core of human culture. Perhaps this can be understood in the following way. People first try to understand their environment in terms of nature and culture: both tempt people, and both dimensions are attached to history, myths and the living conditions of human beings. We interpret the factor as a *Culture* dimension (Table 2).

Factor 3. The two first variables in this factor are 'The urban park or urban open space contains plane and well-cut grass surfaces' and 'It is possible to have a prospect, vistas over the surroundings'. These are followed by several variables with a content of open fields, primarily well-cut grass lawns. We conclude that this factor shows a *Prospect* dimension (Table 3).

Factor 4. This factor contains a long list of variables, and those with the highest factor loadings all concern amusements. We interpret this factor as follows: People are like invited guests to a festivity, where they can eat and drink, watch entertainments and watch other people. Everything is prepared, so they do not have to exert themselves. There are good paths, well lit up, and it is easy to find restrooms and benches. We interpret this factor as revealing a *Social* dimension (Table 4).

Factor 5. The most important variable in this factor is that the green space is experienced as spacious and free. It must have a certain quality of connectedness, so one is not disturbed by too many roads and paths. We interpret and define this factor as a *Space* dimension (Table 5).

Factor 6. This factor has only three variables, however very strong. They all concern the importance of experiencing many species: birds, butterflies, flowers, etc. We suggest that this factor concerns finding a wide range of expressions of life: The dimension is called *Rich in species* (Table 6).

Table 4
Factor analysis, SAS Promax oblique rotation. Factor 4. All variables, qualities in urban green open spaces, related to Factor 4, loadings < ±0.30 not shown.

Variables	Factor loading
It is possible to watch entertainment, like a park concert	0.94
It is possible to watch exhibitions	0.92
It is possible to visit a restaurant or a simpler open-air restaurant in the urban park or the urban open space	0.89
It is possible to shop in market stalls, kiosks, etc.	0.78
There are plenty of people and movements in the urban park or urban open space	0.74
The urban park or urban open space contains roads and paths made of gravel	0.72
The urban park or urban open space keeps special park animals, like swans, ducks and deer	0.66
The urban park or urban open space has general good lighting	0.64
The roads are well lit up	0.63
There is access to restrooms	0.60
There are places in the urban park or urban open space sheltered from the wind	0.59
There are sunny places	0.54
There are shady places	0.52
The urban park or urban open space contains several seats and benches	0.50
It feels safe spending time in the urban park or urban open space	0.44
There are tables and benches	0.38
The urban park or urban open space contain roads and paths with hard surfaces, like asphalt, concrete bricks, etc.	0.33

Table 5
Factor analysis, SAS Promax oblique rotation. Factor 5. All variables, qualities in urban green open spaces, related to Factor 5, loadings < ±0.30 not shown.

Variables	Factor loading
The urban park or urban open space is experienced as spacious and free	0.89
It is possible to find areas not crossed by roads and paths	0.87
The urban park or urban open space has lots of trees	0.58
It is possible to find places where a company of several persons can gather	0.52
There are places in the urban park or urban open space sheltered from the wind	0.49
There are sunny places	0.44
There are shady places	0.42

Table 6
Factor analysis, SAS Promax oblique rotation. Factor 6. All variables, qualities in urban green open spaces, related to Factor 6, loadings < ±0.30 not shown.

Variables	Factor loading
One can detect several animals, like birds, insects, etc.	0.97
The urban park or urban open space consists of natural plant and animal populations	0.96
There are many native plants to study	0.87

Factor 7. The most important variable in this factor is 'The park or urban open space contains many bushes', followed by variables concerning play: 'The park or urban open space keeps animals that children and adults may feed and pet' and 'There is play equipment, like swings, slides, etc.' and variables related to watching active and playing people. Moreover, it is important to feel safe: 'It feels safe spending time in the urban park or urban open space'. We interpret this factor as a shelter or asylum, describing a place, enclosed by bushes and higher vegetation, where people can feel safe, play or simply watch other people being active. We interpret this dimension as a *Refuge* (Table 7).

Factor 8. The variables in this factor all concern being in an undisturbed environment: Silent and calm, not too many people, no noise, no litter. It is important not to be startled, for instance by

Table 7
Factor analysis, SAS Promax oblique rotation. Factor 7. All variables, qualities in urban green open spaces, related to Factor 7, loadings < ±0.30 not shown.

Variables	Factor loading
The park or urban open space contains many bushes	0.93
The park or urban open space keeps animals that children and adults may feed and pet	0.87
There are sandpits	0.77
There is play equipment, like swings, slides, etc.	0.73
It is possible to watch other people being active, playing, practicing sports, etc.	0.58
It feels safe spending time in the urban park or urban open space	0.57
There are tables and benches	0.36

Table 8
Factor analysis, SAS Promax oblique rotation. Factor 8. All variables, qualities in urban green open spaces, related to Factor 8, loadings < ±0.30 not shown.

Variables	Factor loading
The urban park or urban open space is silent and calm	0.94
There are no bikes in the urban park or urban open space	0.89
One is able to spend time in the urban park or urban open space without coming into contact with too many people	0.84
There are plenty of people and movements in the urban park or urban open space	−0.78
There are no mopeds	0.74
It is possible to watch other people being active, playing, practicing sports, etc.	−0.69
The area is clean and well maintained	0.60
There is no traffic noise from the surroundings	0.57
It feels safe spending time in the urban park or urban open space	0.50

Table 9
Arithmetic mean values concerning people's preferences for the eight perceived dimensions of urban green spaces.

The eight perceived dimensions	*N*	Mean	S.D.	Rank
Serene	684	4.33	0.80	1
Space	683	3.87	0.97	2
Nature	684	3.25	0.93	3
Rich in species	683	2.85	0.98	4
Refuge	684	2.83	0.82	5
Culture	684	2.21	0.94	6
Prospect	680	2.19	1.39	7
Social	683	2.10	0.93	8

people on bikes. We interpret this factor as indicating to a retreat, haven, almost a holy place where you feel safe. We call this dimension *Serene* (Table 8).

3.3. People's preferences for the eight perceived sensory dimensions

To discover which one of the eight perceived sensory dimensions people prefer when they visit urban green spaces, an analysis of arithmetic means was conducted. Table 9 shows that the informants have the highest preference for the perceived sensory dimension Serene, followed by Space and Nature. Prospect followed by Social had the lowest preferences, and Prospect also had the highest standard deviation.

3.4. Connection between LS and the perceived sensory dimensions

Do people who report stress, measured by Level of Stress (LS), differ concerning their preferences for the perceived sensory dimensions? In order to detect the connections between LS and each of the eight perceived dimensions respectively, a SAS Pearson Correlation analysis was conducted (data not shown). Positive correlations were found between seven of the eight perceived dimensions and LS. Only Social had a negative correlation with LS, although not significant. Four of the positive correlations between LS and the perceived dimensions were significant: Serene ($p < 0.05$), Space ($p < 0.01$), Nature ($p < 0.01$) and Refuge ($p < 0.01$).

Table 10
SAS General Linear Model, Type I. Model: dependent variable LS = preferences for the perceived sensory dimensions of urban green spaces. Model: $p < 0.01$, $N = 688$.

The eight perceived dimensions	*F* value	*Pr* > *F*
Serene	4.93	+ < 0.05
Space	3.20	+ = 0.07
Nature	6.03	+ < 0.05
Rich in species	1.72	+ Ns
Refuge	6.62	+ < 0.01
Culture	0.12	+ Ns
Prospect	0.15	+ Ns
Social	0.63	− Ns

Table 11
SAS General Linear Model, Type III. Model: dependent variable LS = preferences for the perceived sensory dimensions of urban green spaces. Model: $p < 0.01$, $N = 688$.

The eight perceived dimensions	*F* value	*Pr* > *F*
Serene	0.04	+ Ns
Space	0.02	+ Ns
Nature	6.03	+ < 0.05
Rich in species	2.96	+ = 0.09
Refuge	7.17	+ < 0.01
Culture	0.02	+ Ns
Prospect	0.08	+ Ns
Social	2.83	− = 0.09

In order to investigate how the perceived sensory dimensions together affect LS, a SAS General Linear Model Procedure, Type I and Type III, was performed. Table 10 shows that the total model is significant. The single most significant and positive connections exist between the following perceived dimensions and LS, in order: Refuge, Nature and Serene. Space has a clear tendency ($p < 0.10$), and the connection between LS and Social is negative (however not significant).

The Type III analysis, presented in Table 11, shows the result when each of the dimensions is entered last into the model. The table shows that Refuge has the strongest and most significant positive connection with LS. Moreover, we find that Nature has a significant and positive connection. The previously found significances between LS and Serene and Space are not seen in the Type III analysis. The properties significant for LS in the dimensions Serene and Space may be clearer in the dimensions Refuge and Nature, which could explain why they no longer relate significantly. On the other hand, both Rich in Species (positive) and Social (negative) have a stronger relation to LS ($p < 0.10$). The properties of importance for LS are perhaps more unique in these dimensions.

Finally, a SAS *R*-Square regression analysis was carried out, using LS as the dependent variable. This analysis makes independent regression models, stepwise, using Mallows $C(p)$ to find the optimal model, when Mallows $C(p)$ has its lowest value (Mallows, 1973). All eight dimensions are put into the *R*-Square model. Table 12 shows that the single best model includes Nature, and the best two-variable model includes Nature and Refuge. $C(p)$ shows that including Nature, Refuge, Rich in Species and Social results in the best model.

4. Discussion

4.1. First aim: to identify and describe perceived dimensions in green urban spaces

The first aim of the present study concerned identifying and describing perceived dimensions in urban green spaces. We identi-

Table 12
SAS *R*-Square Stepwise Regression Procedure, Mallow's coefficient, $C(p)$ for finding the optimal model, i.e. the lowest $C(p)$. Model: dependent variable LS = preferences for the perceived sensory dimensions of urban green spaces. $N = 688$.

Model	$C(p)$	Variables in model
1	7.24	Nature
2	4.19	Refuge Nature
3	2.41	Social (neg) Refuge Nature
4	1.16	Social (neg) Rich in species Refuge Nature

fied eight perceived dimensions: Nature, Culture, Prospect, Social, Space, Rich in Species, Refuge and Serene. There are similarities between our findings and earlier research results; some of these similarities are described above (see Section 1.4):

Nature: We interpreted this factor as including an experience of the inherent force and power of nature, designed and manifested on nature's own terms. Many preference studies of outdoor recreation environments, conducted by, e.g., Kaplan and Kaplan (1989) and Herzog (1987), have found that the presence of nature is perhaps the most essential experienced dimension of urban green spaces: the degree to which 'nature' is perceived in contrast to 'non-nature'. This dimension has been identified in many studies and labeled 'Impression of nature' (Grahn and Sorte, 1985); 'Wild' (Berggren-Bärring and Grahn, 1995; Grahn et al., 2005; Maikov et al., 2008); 'Close to nature' (Kyttä and Kahila, 2005); 'Experiencing nature' (Ståhle, 2005); 'Unspoiled nature/mystery' (Stockholms Regionplane-och trafikkontor, 2001); 'Unspoiled and adventurous nature' (Caspersen and Olafsson, 2006), 'Valuable nature site' (Tyrväinen et al., 2007), and 'Nature' (van Herzele, 2005).

Culture: This factor is interpreted as containing an essence of human culture. This can be explained in terms of people's need to understand the surrounding environment in terms of nature or culture. Tuan (1977, 1990), in his dialectical perspective on how people form their values of the environment, distinguished different types of environmental experience depending on the cultural and natural context, where myths and symbols play a major role. In his work *Dominance and Affection* (Tuan, 1984), he claimed that people creatively distort nature through cultural elements, like fountains, ponds and ornamental plants. According to him, this makes the whole environment a kind of pet, satisfying our feelings of power, on the one hand, and of caring for and nurturing a piece of landscape, on the other (Tuan, 1984). This dimension has also been found in many studies and labeled 'Ornamental characteristic' (Grahn and Sorte, 1985); 'Culture' (Berggren-Bärring and Grahn, 1995; Grahn et al., 2005; Maikov et al., 2008); 'Culture and history' (Caspersen and Olafsson, 2006; van Herzele, 2005; Stockholms Regionplane-och trafikkontor, 2001; Tyrväinen et al., 2007) and 'Gardening and splendor', including a 'Magnificent display of flowers' (Ståhle, 2005).

Prospect: The variables in this factor could be summarized as having a content of open and plane areas with a prospect, i.e. vistas over the surroundings. Appleton (1975) claimed that during evolution our ancestors tried to find certain environments where they could settle. One of the most preferred dimensions, and clearly a necessary one, was Prospect: an open area with a view. People, Appleton claimed, instinctually prefer environments that promote survival. One of the most important elements is having visual control over the environment, which allows us to detect dangers. Ulrich (1983), Orians and Heerwagen (1992) and Coss and Moore (2002), among others, have linked this type of preference to the Savannah hypothesis, which claims that the first humans came from a savannah environment. This dimension has been mentioned in several studies and labeled 'Common' (Berggren-Bärring and Grahn, 1995; Maikov et al., 2008; Stigsdotter and Grahn, 2003); 'Prospect' (Ståhle, 2005), 'View and open landscape' (Caspersen and Olafsson, 2006), 'Freedom' (Stockholms Regionplane-och trafikkontor, 2001) and 'Sports-activities characteristic' (Grahn and Sorte, 1985) or 'Opportunities for activities' (Tyrväinen et al., 2007) connected to open green areas.

Social: We interpret this factor as an environment that is equipped for social activities. Gehl (1987) and Gehl and Gemzøe (1996) have claimed that people are mostly interested in other people. Moreover, they have argued that it is of utmost importance to a sustainable, successful city to offer good places, easily accessible, where people can meet, amuse themselves and watch one another. Like the dimension Nature, this dimension has been found in many studies and labeled 'Festive' (Berggren-Bärring and Grahn, 1995; Grahn et al., 2005; Maikov et al., 2008; Ståhle, 2005), 'Service and being together' (Caspersen and Olafsson, 2006; Stockholms Regionplane-och trafikkontor, 2001), 'Good services' (Kyttä and Kahila, 2005), 'Town park, people's park characteristic' (Grahn and Sorte, 1985) and 'Facilities' (van Herzele, 2005).

Space: This factor is understood as a green environment, experienced as spacious and free and having a certain amount of connectedness. Stephen Kaplan (1990, p. 13) wrote about extent, a quality important in recreational environments: "[. . .] *restorative settings are often described as 'being in a whole different world'. Two properties are important to this experience: connectedness and scope; together they define what I mean by extent. Scope requires that the environment is experienced as large enough that one can move around in it without having to be careful about going beyond the limits of the model that one is running. To have connectedness, the various parts of the environment must be perceived as belonging to a larger whole. Without that, one must repeatedly expend effort to find the model that is appropriate to the current momentary situation*". This dimension is very clear, has been mentioned in many studies and labeled 'Space' (Berggren-Bärring and Grahn, 1995; van Herzele, 2005; Maikov et al., 2008; Stigsdotter and Grahn, 2003), 'Spacious' (Kyttä and Kahila, 2005), 'Space and freedom' (Tyrväinen et al., 2007), and 'Feeling of being inside a forest' (Caspersen and Olafsson, 2006; Stockholms Regionplane-och trafikkontor, 2001).

Rich in species: This factor solely comprises variables demonstrating the importance of finding a wide range of expressions of life: many birds, butterflies, flowers, etc. In their Biophilia hypothesis, Wilson (1984) and Kellert and Wilson (1993) have suggested that people have a strong and inherent interest in finding signs of life in their environment, as manifested by different species. This dimension has been found in other studies and labeled 'Rich in Species' (Berggren-Bärring and Grahn, 1995; Grahn et al., 2005; Gyllin and Grahn, 2005; Maikov et al., 2008; Stockholms Regionplane-och trafikkontor, 2001), and 'Richness in nature' (Caspersen and Olafsson, 2006).

Refuge: We understood this factor as an enclosed and safe environment, where people can play or watch other people being active. Appleton (1975) suggested that during evolution our ancestors tried to find a safe area where they could hide. This quality, in addition to Prospect, was a dimension of utmost importance in environments where people settled. Appleton called this dimension Refuge (Appleton, 1975). The dimension is related to other results, variously labeled 'Pleasure Garden' (Grahn et al., 2005; Maikov et al., 2008), 'Play-Inspiring characteristic' (Berggren-Bärring and Grahn, 1995), 'Play-activities characteristic' (Grahn and Sorte, 1985), and 'Green oasis' (Ståhle, 2005), while Kyttä and Kahila (2005) found two factors: 'Cozy' and 'Child friendly'. Together they can be interpreted as encompassing the same phenomena.

Table 13
Summary of research reports identifying and describing experienced dimensions in green environments similar to those found in the present study.

Research reports	Experienced sensory dimensions in the present study							
	Nature	Culture	Prospect	Social	Space	Rich in species	Refuge	Serene
Grahn and Sorte (1985)	X	X	X	X			X	X
Berggren-Bärring and Grahn (1995)	X	X	X	X	X	X	X	X
Stockholms Regionplane-och trafikkontor (2001)	X	X	X	X	X	X		
Grahn et al. (2005)	X	X	X	X	X	X	X	X
van Herzele (2005)	X	X		X	X			X
Kyttä and Kahila (2005)	X			X	X		X	X
Ståhle (2005)	X	X	X	X			X	X
Caspersen and Olafsson (2006)	X	X	X	X	X	X		
Tyrväinen et al. (2007)	X	X	X		X			X
Maikov et al. (2008)	X	X	X	X	X	X	X	X

Serene: This factor is about being in an undisturbed, silent and calm environment, which can be interpreted as an environment for retreat—a virtually holy and safe place. Jensen (1998) found that quietness was one of the primary dimensions motivating people to visit green spaces. This dimension has been found in several studies and labeled 'Peacefulness' (Berggren-Bärring and Grahn, 1995; Grahn and Sorte, 1985; Grahn et al., 2005), 'Serene' (Maikov et al., 2008), 'Quietness' (van Herzele, 2005) and 'Calm' (Ståhle, 2005). Tyrväinen and her associates (Tyrväinen et al., 2007) found a pair of factors: One positive – 'Peace and tranquility', and one negative – 'Noisiness', while Kyttä and Kahila (2005) found two factors: 'Peaceful vs. Restless, noisy' and 'Tidy vs. Untidy'. Together they seem to capture the same phenomena.

Consequently, our findings are in line with previous results. Despite the different methods used (qualitative, quantitative or literature surveys), the different target groups addressed (organizations or individuals) and the different contexts studied (urban green spaces or countryside), the results are very similar. The dimensions have been identified and described one by one, often many decades ago. Moreover, many researchers have suggested that experienced qualities in green spaces can be divided into certain classes (see Table 13). As we understand them, these qualities have been detected and described in a way that makes it possible for us to compare them with our results: van Herzele (2005) found five dimensions – all of them detected in the present study. Grahn and Sorte (1985) identified six dimensions – all of them discovered here as well. Stockholms Regionplane-och trafikkontor (2001) and Caspersen and Olafsson (2006) have mentioned seven dimensions, six of them detected in the present study. What is interesting is that Stockholms Regionplane-och trafikkontor (2001) claimed that 'Serene' is of the utmost value, however so crucial and important that is not necessary to bring it up as an eighth dimension in planning. Berggren-Bärring and Grahn (1995), Grahn et al. (2005) and Maikov et al. (2008) have identified eight dimensions—all of them found in the present study, yet in two of the studies (Berggren-Bärring and Grahn, 1995; Grahn et al., 2005) they were found more or less in the opposite order: The Serene dimension was their first factor and the Nature dimension their last. Kyttä and Kahila (2005) found nine positive and nine negative dimensions. Most of them were pairs of dimensions such as 'Peaceful–Restless, noisy'. However, in their further analyses, only the positive dimensions were used. Seven of these dimensions have been found here as well. Tyrväinen and her associates found eleven dimensions. Eight dimensions were positive and three negative. Five of the positive dimensions and one of the negative dimensions were found here too. Lastly, Ståhle (2005) found ten dimensions. Six of them were discovered in the present study.

Stockholms Regionplane-och trafikkontor (2001), Ståhle (2005), Kyttä and Kahila (2005), Tyrväinen et al. (2007) and Caspersen and Olafsson (2006) have identified dimensions not found here. Most of them are activity classes, as they have mixed activities with qualities connected to the environment. Ståhle (2005) found four activity classes: 'Picnic activities', 'Water activities' (e.g., playing in water, bathing, swimming), 'Cultivating activities' (e.g., growing vegetables, keeping small animals like rabbits and guinea pigs) and 'Activities connected to big green commons' (e.g., soccer, temporary events). Stockholms Regionplane-och trafikkontor (2001) and Caspersen and Olafsson (2006) have a seventh factor: 'Sports-activities characteristic'. In the present study, activities are completely separated from qualities attached to the environment. Tyrväinen et al. (2007) found the factor 'Forest feeling'—that the area feels like a "real" forest. We have focused our study on urban green spaces. In spite of this, a forest feeling could be related to our factor 'Nature', however being more of an identity dimension. Tyrväinen and her associates (Tyrväinen et al., 2007) also found two factors related to security: 'Scariness' – that the area feels dangerous or threatening, and 'Unpleasantness' – that the area is neglected, abused or damaged. Kyttä and Kahila (2005) found a factor related to security as well: 'Secure', which we have found to be an important property in several dimensions, however most obvious in Refuge. Furthermore, Kyttä and Kahila (2005) found the dimension 'Good connections', which concerns traveling to the site. Tyrväinen and her associates found two factors concerning aesthetics: 'Beautiful landscape' and 'Attractive park'—the latter likewise connected to exceptional beauty. In the present study we have avoided all words and concepts concerning plain aesthetics.

Nature is a characteristic found in all nine studies, including this one. Social is lacking only in the study by Tyrväinen et al. (2007) and Culture is lacking only in the study by Kyttä and Kahila (2005). In studies relating outdoor life and preferences to green spaces, a more anthropocentric perspective on green spaces is needed. Nature is what distinguishes green spaces from the man-made landscape, Social is one of the most important qualities of green spaces for people, and Culture is revealed in how the green space is designed and managed. This may explain why these three dimensions are distinguished from the others.

4.2. Second aim: identify the perceived dimensions people in general prefer

Our results show that Serene was the most preferred dimension, followed by Space and Nature. Rich in species and Refuge were found in the middle, while Culture, Prospect and Social were the least preferred. Jensen and Koch (1997) and Tyrväinen et al. (2007) found that 'Peacefulness' was the most valued quality among the visitors they asked. Peacefulness does not mean that the area is absolutely quiet, you can listen to the wind in the trees and you can listen to birds, but you are not affected by noise. Berggren-Bärring and Grahn (1995) found that the dimensions 'Serene', 'Space', 'Wild' and 'Rich in Species' were connected to the largest urban green spaces in the cities they investigated.

Kaplan (1990) claimed that one of the most important qualities for a recreation area is its compatibility. That is, what you as a visitor want to find and want to do is exactly what the area is suitable for and allows you do. According to Gibson's (1979) theory, the area affords you the right opportunities. Jensen (1998) found five dimensions of motivation or push-factors that make people want to go out in nature areas, and these could be linked to both compatibility and affordances. These were 'Experiencing nature', such as finding areas with mystery and wildness, coming in close contact with different species, enjoying views of the landscape and enjoying sounds and smells from nature. In our study, the dimensions Nature, Rich in species, Prospect, Serene and Refuge might together satisfy this need.

Another dimension of motivation in Jensen's (1998) study was 'Peace and quiet'—finding a place where it is quiet, a place far away from densely built-up and populated areas, finding a change from everyday city environments. The present dimensions Serene and Space can together satisfy this need. A third dimension of motivation was 'Social stimulation', such as meeting new people, talking to a variety of new people, showing that you dare to do something, and being with friends. In our study, the dimension Social can satisfy this need. The two last dimensions of motivation were 'Physical exercise' (e.g. taking a walk) and 'Strengthening family ties' (being in places together with my family); these are not clearly connected to any of the dimensions found in our study.

From the above, we can see that Serene satisfies several needs. You are allowed to experience different sounds in nature, and are not affected by noise and crowds of people.

4.3. Third aim: identify the perceived dimensions people reporting stress prefer

As stated earlier, in studies relating outdoor life and preferences to green spaces, a more anthropocentric perspective on green spaces is needed. However, for people experiencing stress, dimensions other than Social and Culture are more preferred, such as Refuge, Nature and Serene. This could be depicted as toning down the anthropocentric perspective, allowing a more empathic and participating perspective to appear for individuals experiencing stress. Such individuals need to be involved on a more basic level in the green space. The eight dimensions discovered and described here consist of messages that manifest themselves through many different sensations, perceived through our vision, hearing, sense of smell, locomotion, etc. Hence, the dimensions should be able to communicate with many aspects of the individual's body, muscles, thoughts and feelings, and thus the individual's preferences and decisions to visit the area or not.

Earlier research has shown that the most ill and vulnerable individuals – those striving to find balance within them – seem to be most sensitive to the perceived dimensions in the environment (Ottosson and Grahn, 2005, 2008; Ulrich, 1999). The sensory experiences of outdoor areas (green areas as well as more built areas) may be of the utmost importance to whether or not stress-reduction effects are felt. Our results show that individuals reporting high levels of stress have preferences for the dimensions Refuge and Nature. To a certain degree, Rich in Species, Serene and Space are important, while Social is a dimension that could be interpreted as adding to the total stress burden. A person who is affected by stress finds it increasingly difficult to understand, sympathize with and tolerate other people (Währborg, 2002). Ulrich (1999) pointed out that people have an inherent capacity to interpret dimensions in nature in terms of stress reactions. We easily adapt our stress reactions to appropriate levels in nature, while urban areas are more difficult to interpret through our reflexes. Kaplan (1990) talked about the importance of restoring directed attention, where nature is the optimal place for using involuntary attention and resting directed attention. According to Kaplan (1990), characteristics that are good for mentally fatigued people are an impression of nature (the dimension Nature), the experience of extent (the dimension Space) and the experience of fascination (the dimension Rich in Species).

Ayres (1983), Bucci (2003) and Ehrenzweig (2000) have all emphasized the importance of sensuous experiences, where unconscious information can be stored. The Refuge is a dimension that involves opportunities, or affordances, to be in a small safe place, where you can be alone, come close to the vegetation, and have possibilities to use all your senses.

4.4. Fourth aim: identify a combination of the perceived dimensions people reporting stress prefer

Our results show that if we want to create an area with one single dimension, Nature would be the optimal solution. However, Mallows coefficient shows that a combination of Nature and Refuge would be a better solution, especially if there are no signs of the dimension Social at all. Our interpretation is that an area offering these dimensions would be more preferred, because it offers better possibilities for restoring various capacities.

In the Type III analysis, Nature and Refuge were the only dimensions with a positive significance. The characteristics most preferred by people reporting the highest levels of stress are also found in the dimensions Serene and Space, but these certain characteristics are probably even stronger in the dimensions Refuge and Nature, which causes Serene and Space to disappear in the Type III analysis.

Basically, experienced qualities in urban green spaces should be able to meet the individual's and/or the group's vital needs, i.e. beliefs, desires, emotions, etc. Individuals who report stress are most sensitive to the environment, and hence most difficult to consider. Based on the theories above, we learn that we perceive our environment through all our senses and that the information is processed and stored at the subsymbolic, symbolic imagery and symbolic verbal levels (Bucci, 2003). People suffering from stress have difficulties interpreting their environment, and dissociation between the senses, emotions and cognition can occur (Bucci, 2003). Moreover, those suffering from stress instinctively seek out sheltered areas, and do not want to be social (Ulrich, 1999; Währborg, 2002). We interpret the present results as showing that people who report high levels of stress need peaceful, more undifferentiated areas where they have a chance to make contact with their basic senses and more deeply stored subsymbolic information. Because dimensions and characteristics in our environment are interpreted immediately through cognition and emotions and through our pre-linguistic vitality affects (Stern, 1985, 1993), symbols from nature have a chance to spark creative processes that are important in the restoration process (Bucci, 2003; Ottosson and Grahn, 2008; Searles, 1960). Rich in Species entails the presence of fascinating objects, which Kaplan (1990) found to be crucial to restoring an individual affected by mental fatigue. A combination of the dimensions Refuge, Nature and Rich in Species, where the dimension Social is toned down, could be interpreted as being most preferred by people reporting the highest levels of stress, and thereby such a combination may offer the optimal place for recovery.

5. Conclusions and future perspectives

Historically, public health has always been an important perspective in city planning. Thanks to developments in modern medicine as well as improved living standards and living environments with, e.g., better hygiene, several communicable diseases

have nearly disappeared (Puranen, 1984). However, other threats to public health have developed (WHO, 2006, 2008). People in the West are living their lives farther and farther from nature. The majority of Swedes now live in cities and, moreover, spend most of their time indoors (Qvarsell and Torell, 2001). This trend has also been observed in other developed countries all over the world, not least in the US (Pergams and Zaradic, 2006). This and other trends in the developed world are connected to a more sedentary and stressful life (Pergams and Zaradic, 2006; Währborg, 2002).

Today, when recreational areas are analyzed and described, for instance at the prospect of exploitation, in Sweden, and presumably in many other countries, it is clear that decision-makers have not been given a fair chance to assess the importance of such areas to the outdoor life of the town population (Grahn et al., 2005; Ståhle, 2005). The qualities in urban green areas are most often not appropriately accounted for in the maps and documents that form the basis for different kinds of decisions. When urban green spaces are described, no values are presented that refer to people's outdoor life, their preferences, needs or health (Grahn et al., 2005; Ståhle, 2005). The present findings suggest that preferred urban green areas play specific roles and embrace qualities of clear importance to health and outdoor life.

In conducting the present study, our goal has been to deepen our understanding of why certain urban green spaces may be connected to mental health. This concerns how humans perceive and process sensory information, and it also concerns preferences. Here, we have investigated individual preferences using a representative sample of the Swedish adult population.

The results identify and describe eight perceived sensory dimensions in green urban spaces: Nature, Culture, Prospect, Social, Space, Rich in species, Refuge, and Serene. People in general prefer the dimension Serene, followed by Space, Nature, Rich in Species, Refuge, Culture, Prospect and finally Social, ranked in order. However, the dimensions Refuge and Nature are most strongly correlated to highly stressed individuals' preferences, indicating a need to find the most restorative environments. A combination of Refuge, Nature and Rich in Species, and a low or no presence of Social, is the most preferred urban green space, and could be interpreted as the most restorative environment for stressed individuals.

In the present debate on the dense city contra the sprawled city, the dense city is often considered as a suitable direction for future city planning, the idea being that such cities promote sustainable development (Hardy, 2004). Yet the health-promoting perspective on urban green spaces also concerns the sustainable development of cities. New building within city limits and densification of the city may result in the thinning out and disappearance of the very value of parks and other natural and recreational areas, because the perceived dimensions appreciated by people are closely tied to factors such as quietness, size and shape. Some of the most important perceived dimensions for people reporting high levels of stress, and thereby for promotion of health, are also the most sensitive to disruption, because these dimensions – Serene, Space and Rich in Species – require large land areas (Berggren-Bärring and Grahn, 1995). Thus, if these dimensions are thinned out and thereby disrupted, the health-promoting qualities of parks and other natural and recreational areas may be lost. The results presented here should be considered with a view to future urban planning, where urban green spaces can be seen as a resource of importance to public mental health. However, before the eight perceived sensory dimensions can be used by practitioners as tools to promote health through design and urban planning, more research is needed to understand these dimensions, and how they can be detected, developed and maintained.

Acknowledgements

This paper was made possible by financial support from The Swedish Research Council Formas. We would like to thank our statistician, Associate Professor Dr. Jan-Eric Englund, Swedish University of Agricultural Sciences, Alnarp, for his kind assistance.

Appendix A.

Factor analysis, SAS Promax oblique rotation, of dimensions in green spaces. Rotated Factor Pattern. $N = 643$ (adults only). Loadings of each of the scored items, forming the basis of analysis (loadings < ±0.30 not shown).

Variables	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8
Nature quality	0.71							
Wild and untouched	0.63							
Free growing lawns	0.54							
Possible to light a fire	0.50							
Hilly	0.44							
Fountains		0.73						
Statues		0.65						
Foreign plants		0.65						
City park characteristic		0.57						
Pond, canal		0.52						
Flowers		0.50						
Wooded pasture quality		0.46						
Plane, well-cut grass			0.87					
Prospect			0.78					
Cut lawns			0.76					
Soccer fields on grass			0.68					
Soccer fields on gravel			0.50					
Soccer fields are lit up			0.48					
Small ball grounds			0.47					
Showers, changing rooms			0.43					
Entertainment				0.94				
Exhibitions				0.92				
Restaurant				0.89				
Market stalls				0.78				
Paths made of gravel				0.72				
Special park animals				0.66				
General good lighting				0.64				
Roads well lit up				0.63				
Access to restrooms				0.60				
Places sheltered from the wind				0.59	0.49			
Sunny places				0.54	0.44			
Shady places				0.52	0.42			
Several seats and benches				0.50				
Tables and benches				0.38			0.36	
Paths with hard surfaces				0.33				
Experienced as spacious					0.89			
Areas, not crossed by paths					0.87			
Lots of trees					0.58			
Places where people can gather					0.52			
One can detect several species of animals						0.97		
Natural plant and animal populations						0.96		
Many native plants to study						0.87		
Many bushes							0.93	
Animals that people may feed and pet							0.87	
Sandpits							0.77	
Play equipments							0.73	
Feels safe	0.49			0.44			0.57	0.50
Silent and calm								0.94
No bikes								0.89
Not crowded	0.47							0.84
Plenty of people				0.74				−0.78
No mopeds								0.74
Watching people being active							0.58	−0.69
Clean and well maintained								0.60
No traffic noise								0.57
Variance explained by the factor, ignoring other factors	5.62	7.10	4.88	5.18	2.38	6.19	2.13	2.23

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