



Soundscapes - Nature and Restoration



From environmental to workplace health

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Soundscape: definitions, standards, references

- “The soundscape is any acoustic field of study”(Schafer, 1977)
Therefore: examining the systematic relationship between humans and the acoustic environment (= soundscape ecology)
- Soundscape is a contextually derived delineation of a space (place) - based on a perceived (sonic) environment (European COST Action TD 0804, 2009)
- Soundscape is an “acoustic environment as perceived or experienced and/or understood by a person or people, in context.” (ISO/FDIS 12913-1 2014)
- *In preparation: Acoustics — Soundscape — Part 2: Methods and measurements*

"Recent Advances in Soundscape Research" Special Issue of Acta Acustica united with Acustica 92(6),(2006)

"Soundscape and its Applications", Special issue in JASA (2013).

"Applied Soundscapes: Recent Advances in Soundscape Research" in Applied Acoustics, Volume 74, Issue 2, Pages 223-300 (February 2013)

"Soundscape and the built environment". Jian Kang & Brigitte Schulte-Fortkamp (eds), in press: CRC-Press

What are the key aspects when we are talking about soundscapes?

The key word is: **Perception**

The reference is: **Context**

The outcome is dependent on:

Personal experience and preferences

The actual activity to perform: cognitive, mental, physical

Place related aspects: density, comfort, social relations etc.

Relative match with: intentions, expectations, purposes

Classical view

Major pathways of noise to main health effects

Noise Exposure: measured as intensity

Masking of
acoustical
Information

Demand for
Attention
Distraction

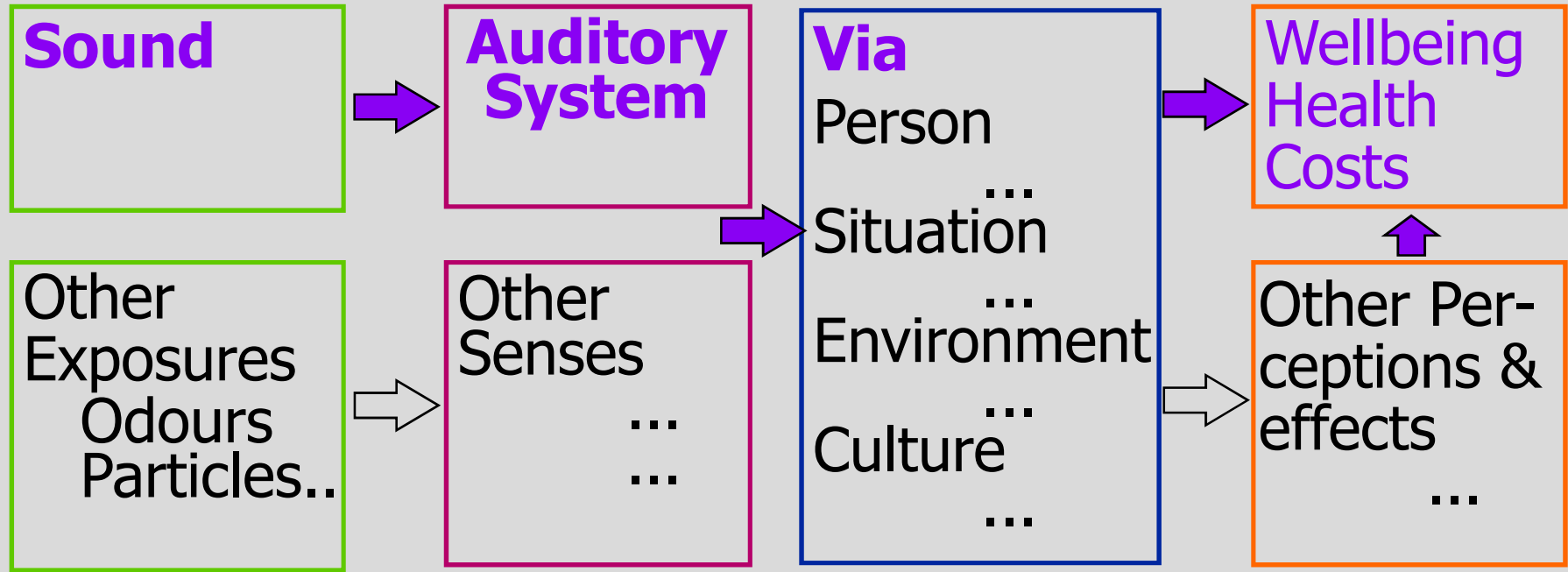
Psychophysiol.
Activation

Interference
Anger
Helplessness
Anxiety

**Cognitive impairment, Annoyance, Sleep problems,
Cardio-vascular disease**

Model of Sound Perception and Effects

EXPOSURE **SENSES** **MODERATION** **EFFECTS**



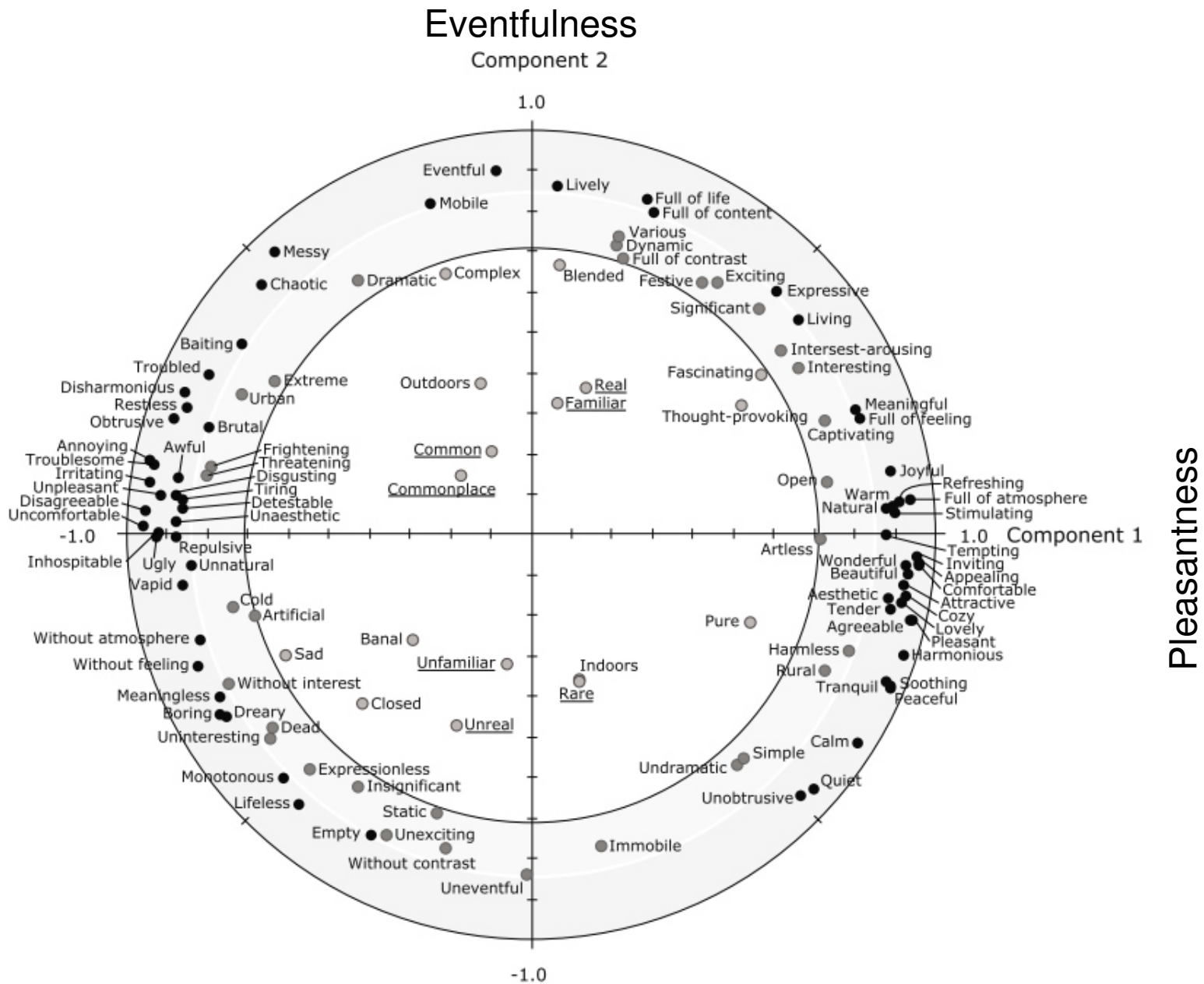
Soundscape → assessment

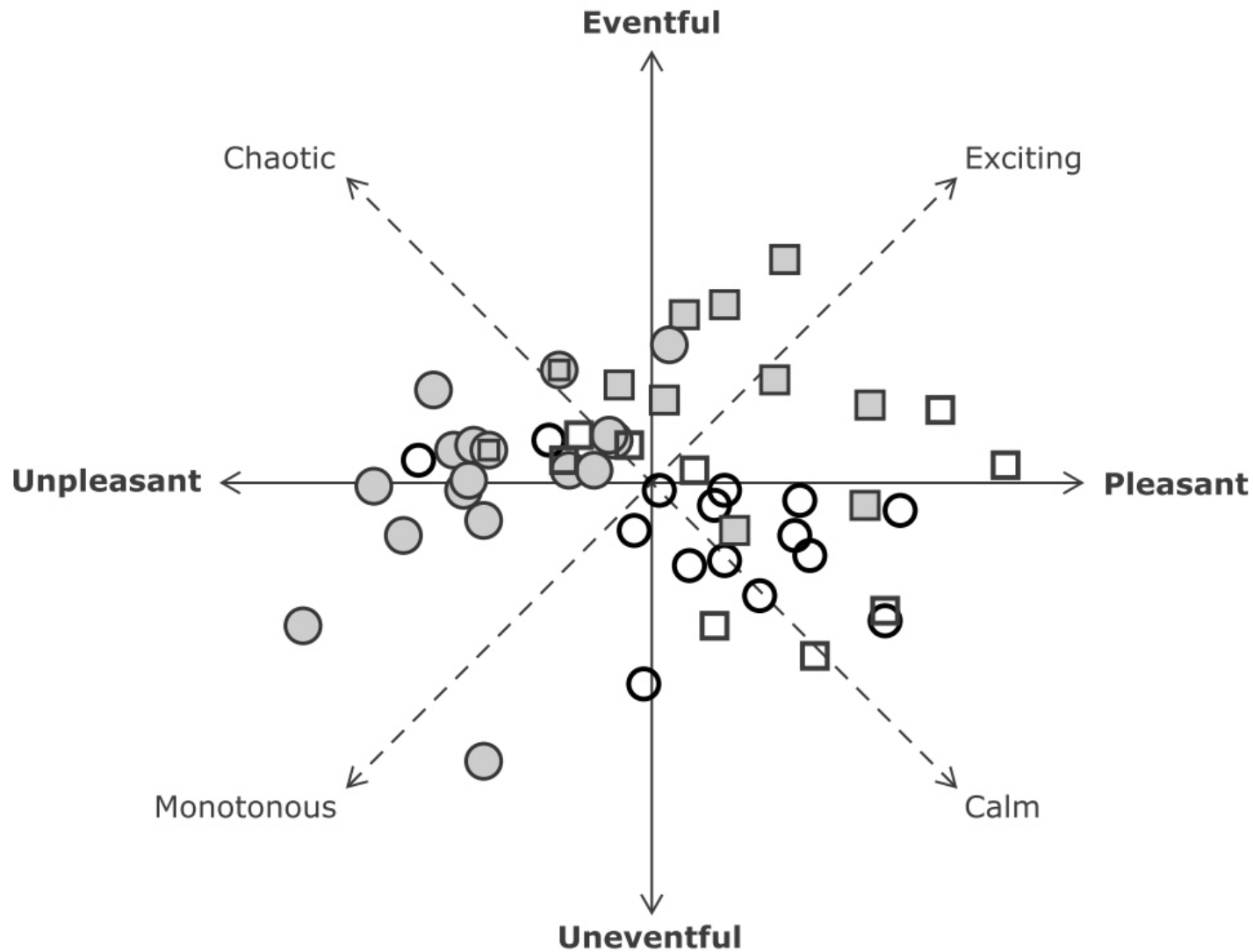


“Objective”

“Subjective” & “Objective”

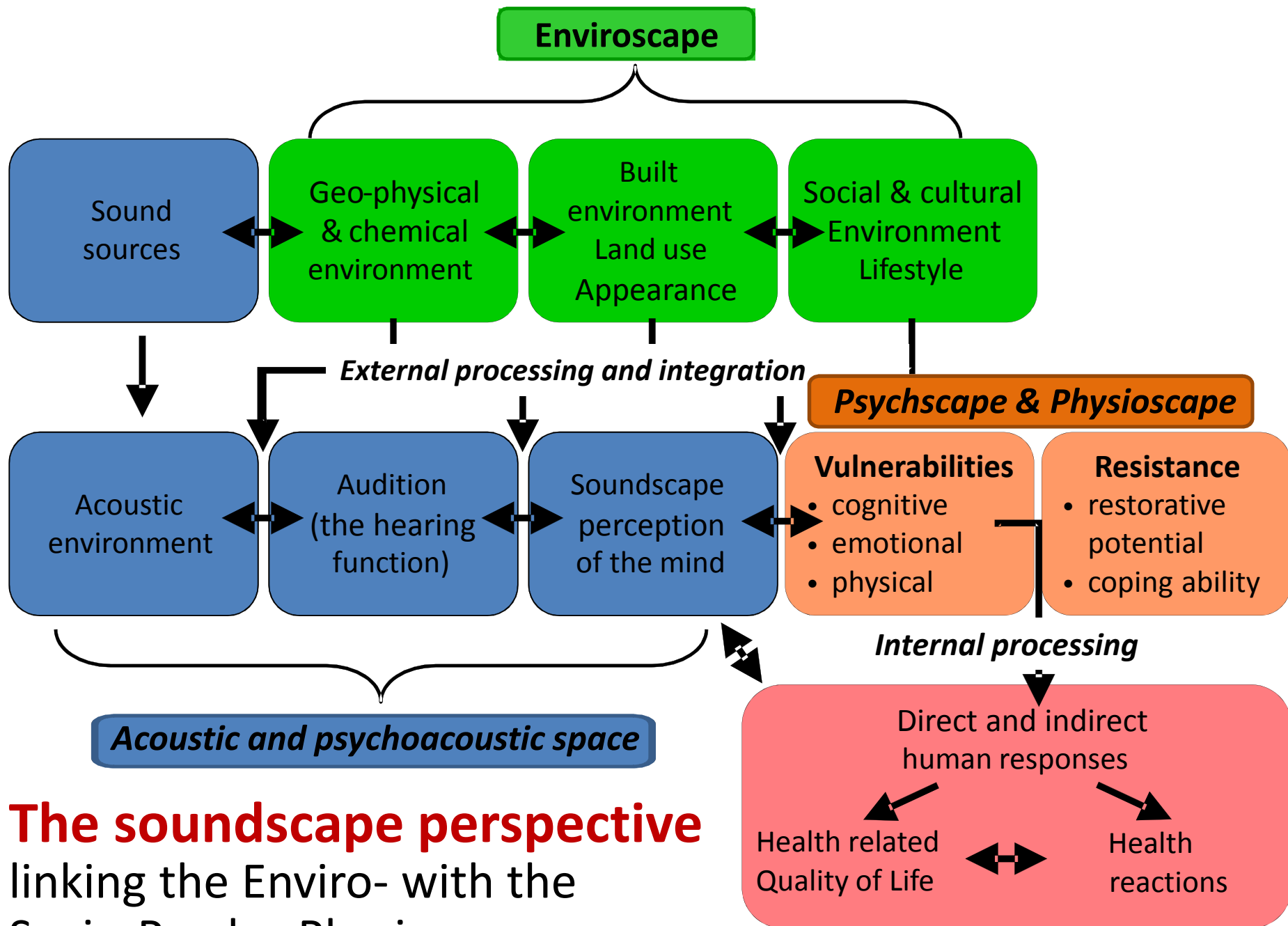
Source: Axelsson et al. 2010





Source: Axelsson et al. 2010

Fig. 4. Component scores of the 50 soundscape excerpts in Pleasantness and Eventfulness: Symbols represent dominant sound-categories: human sounds (filled squares), technological sounds (filled circles), natural sounds (open squares), and no dominant sound-category (open circles).



The soundscape perspective
linking the Enviro- with the
Socio-Psycho-Physioscape

Classical versus soundscape approach

Environmental Noise Management Approach	Soundscape Approach
sound managed as <i>a waste</i>	sound perceived as <i>a resource</i>
focus is on <i>sounds of discomfort</i>	focus is on <i>sounds of preference</i>

Source: Brown, A.L. 2010, Soundscapes and environmental noise management, Noise Control Eng. J., vol. 58, pp. 493-500

The links between sound and nature

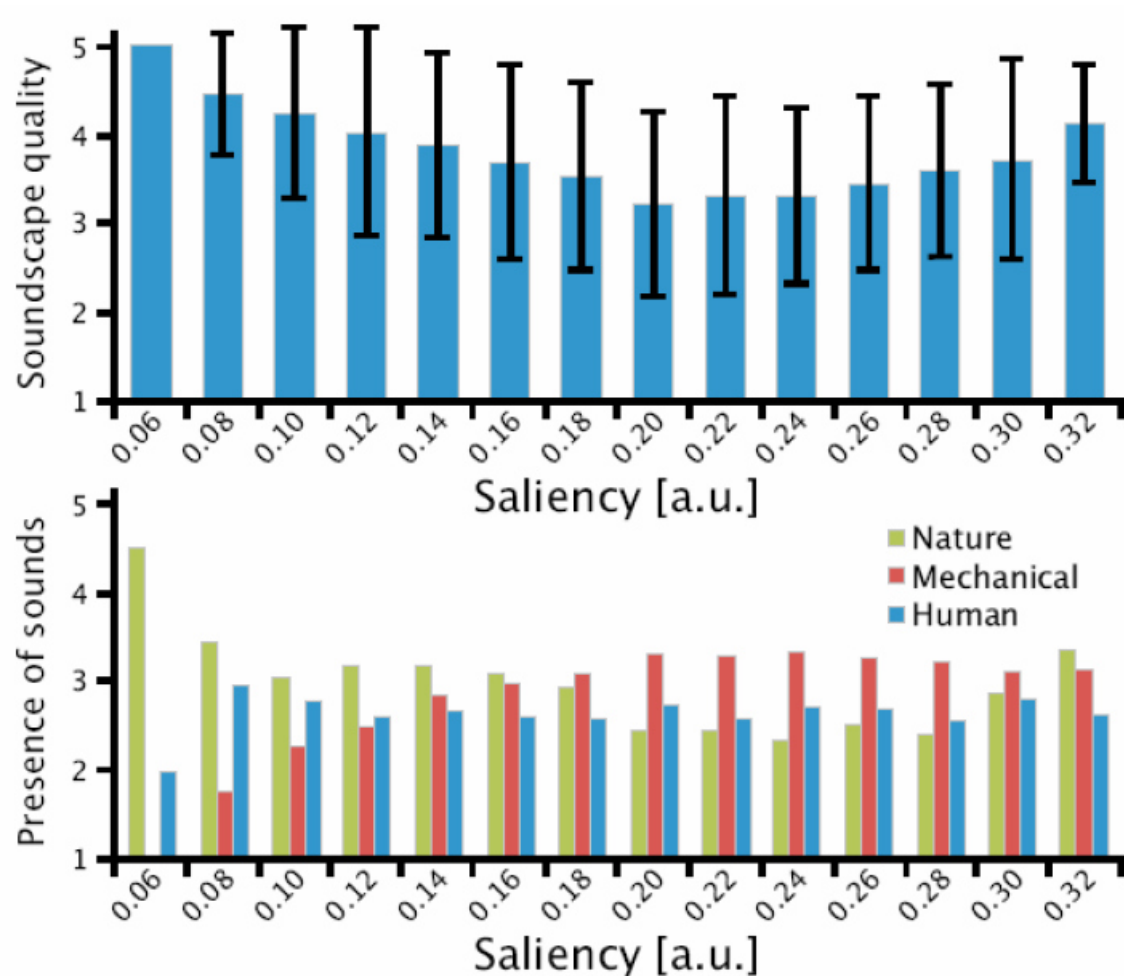
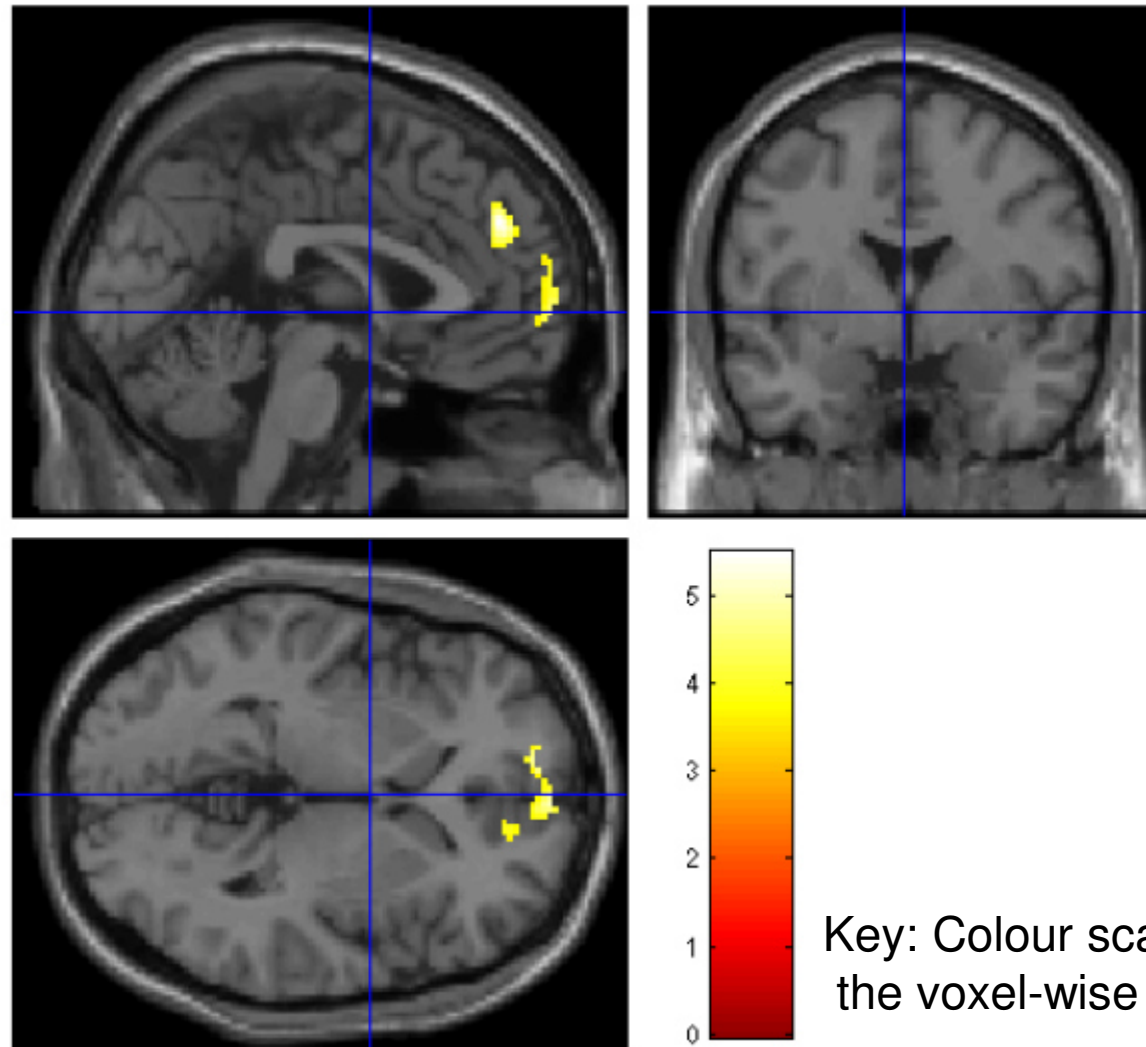


Figure 1. Rated soundscape quality and perceived presence of sounds generated by different sources, as a function of average saliency (data from the Stockholm study: Nilsson et al. 2007)

Watts et al. 2009 utilized an experimental design by which it has been possible to isolate visual (landscape) effects in modulating the response to auditory inputs. The A-weighted levels in both cases is exactly 65 dB(A). Specifically it has been shown that responses in the medial prefrontal cortex are linked directly to activity in the auditory cortex under tranquil conditions (beach) but not under non-tranquil conditions (motorway).



How to manage soundscapes?

- Reduction of annoyance by design (psychoacoustic sound design in planning)
- Improvements by implementation of sound preferences
- Masking
 - Auditory masking of unwanted sound
 - Certain sounds inaudible for a minimum amount of time
- Enrichment („more colourful“)
 - Sound quality improvements
 - Environmental quality improvements (visual, other sensoric qualities)

How to bring soundscapes into practice?

- By changing the sonic environment (bottom down)
- By changing the context (bottom down)
- By negotiation via preferences (bottom up)
- By evidence: showing benefits, cost-effectiveness, feasibility (bottom up)

Restorative Environments

- The concept of restoration is interrelated with both – the stress and the salutogenetic perspective
- The concepts of restoration and salutogenesis have, however, developed largely in parallel with only few interactions
- Both share with salutogenesis studies a positive perspective on circumstances that promote health and well-being
- Research on restorative environments differs from salutogenesis studies in its emphasis on resource depletion, renewal, and consequently resource management
- The study of restorative environments provides a needed complement to inquiries into stress and coping

(Saegert, 1976; Saegert & Winkel, 1990, Hartig, 2001, 2008; Hartig, Bringslimark, & Patil, 2008)

Where does the restoration perspective complement?

	Stress Perspective	Coping Perspective	Restoration Perspective
Theoretical Premise	Heavy demands can undermine adaptation.	Readily available resources support adaptation.	Adaptation requires periodic restoration.
Practical Premise	Interventions can eliminate or mitigate demands.	Interventions can ensure the availability of resources.	Interventions can enhance opportunities for restoration.

From Hartig, Bringslimark & Patil (2008); Hartig (2008)



**Two types of information
are necessary**

**Nature-health relationships in the
built environment**

**Nature-design relationships in the
built environment**

Why is nature related to restoration & health

- Humans are aesthetically attracted to natural contents and to particular landscape configurations (Eco-Evolution)
 - Prospect-refuge theory (Appleton 1975) „to see (prospect) but not be seen (refuge)“ is based on habitat theory (Darwin)
 - The Biophilia Hypothesis (E.O. Wilson, 1984, S.R. Kellert and E.O. Wilson, The Biophilia Hypothesis, 1993, E.O. Wilson, 2007).
 - the preference matrix Kaplan and Kaplan (1989)
 - The savanna hypothesis (Orians & Heerwagen, 1992)
- Research has shown that biophilic features of environments have mostly positive consequences for psychological, physical and social well being
- Current evidence shows effects at various levels (longevity, mortality, morbidity, self-reported health, beneficial change in cognition and emotional and physiological markers of stress (Bowler et al. 2010, Bratman et al. 2012, Keniger et al. 2013; Beute & de Kort 2014; Haluza et al. 2014, Hartig et al. 2014, Ryan et al. 2014)
- Studies have shown these effects in a wide variety of settings, from offices to hospitals, residential areas and community spaces.

Theories: How does nature work

- Stress reduction theory (SRT from Ulrich 1991): Based on psycho-evolutionary theory: Viewing unthreatening nature should help people become restored from stress by reducing negative affect, increasing positive affect, and decreasing physiological arousal
- Attention restoration theory (ART from Kaplan and Kaplan 1989): Recovery from directed attention fatigue through experience of natural stimuli. Focused on cognitive processes and responses.
- The Perceptual Fluency Account (PFA) of restoration (Joye 2007): PFA views attention restoration and stress reduction (to a considerable extent) as by-products of fluent processing - rather than to obscure evolutionary factors.

The classic example

- In a clinical context, Ulrich (1984) found an effect of view content on recovery after surgery. He found that patients with a natural view had a shorter length of stay, received less negative notes from the nurses, and required less pain medication than patients overlooking a brick wall.

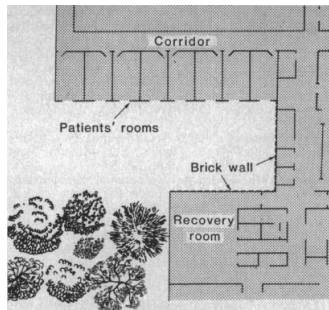
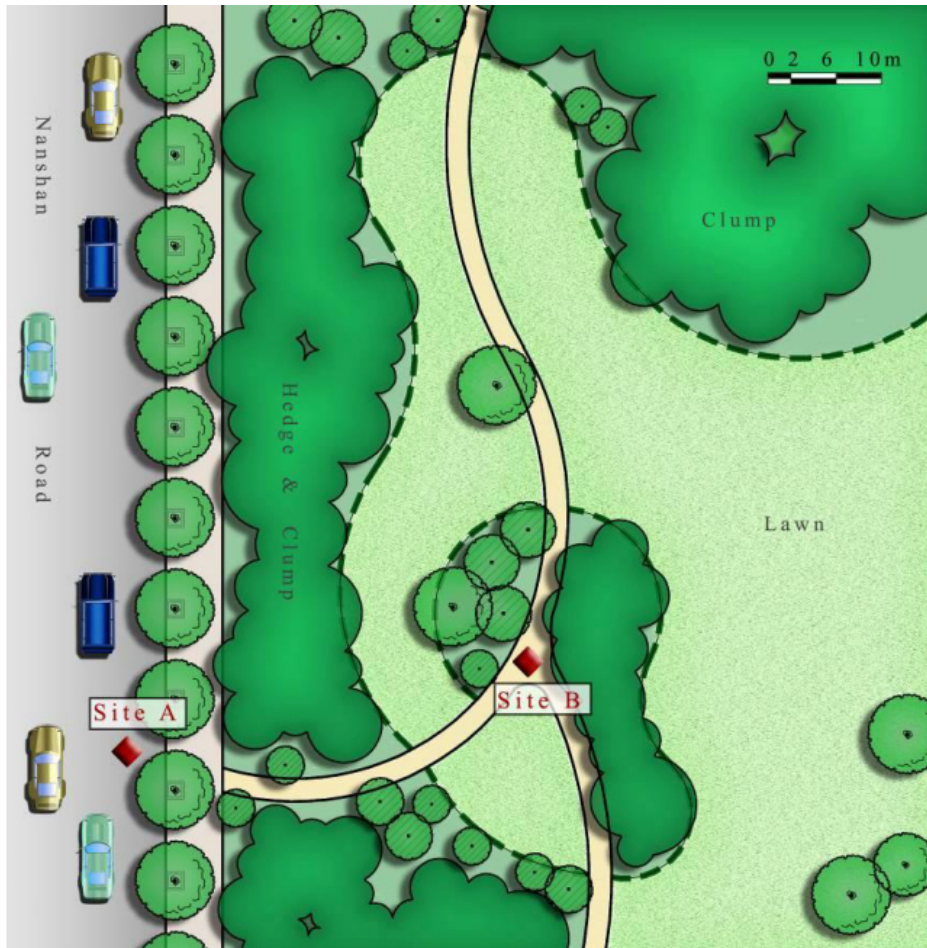


Table 1. Comparison of analgesic doses per patient for wall-view and tree-view groups.

Analgesic strength	Number of doses					
	Days 0-1		Days 2-5		Days 6-7	
	Wall group	Tree group	Wall group	Tree group	Wall group	Tree group
Strong	2.56	2.40	2.48	0.96	0.22	0.17
Moderate	4.00	5.00	3.65	1.74	0.35	0.17
Weak	0.23	0.30	2.57	5.39	0.96	1.09

- In an office setting R.Kaplan (1993) observed effects of view content on reported health as well. People with a more natural view at work reported better subjective health



A typical integrated study

Combined approach: subjective (a questionnaire) and objective: two videos - showing a traffic scene (site A) and a plant scene (site B) were shown to 40 participants on video glasses and electroencephalo-gram recordings were taken.

The LAeq value was 68.6 dB in both cases.

Subjective results: 90% of the subjects believed that landscape plants contribute to noise reduction and that 55% over-rated the plants' actual ability to attenuate noise.

Objective results: highly significant asymmetry between the EEG activity of the vegetation scene and traffic scene groups - regardless of whether urban sounds accompany the visual observations: Mainly through synchronization of the beta frequency band and the desynchronization of the alpha frequency band, indicating that landscape plants can moderate or buffer the effects of noise

Yang, F., Bao, Z. Y., & Zhu, Z. J. (2011).

An Assessment of Psychological Noise Reduction by Landscape Plants.

International Journal of Environmental Research and Public Health, 8(12), 1032–1048. doi:10.3390/ijerph8041032

The outcomes investigated in a current review

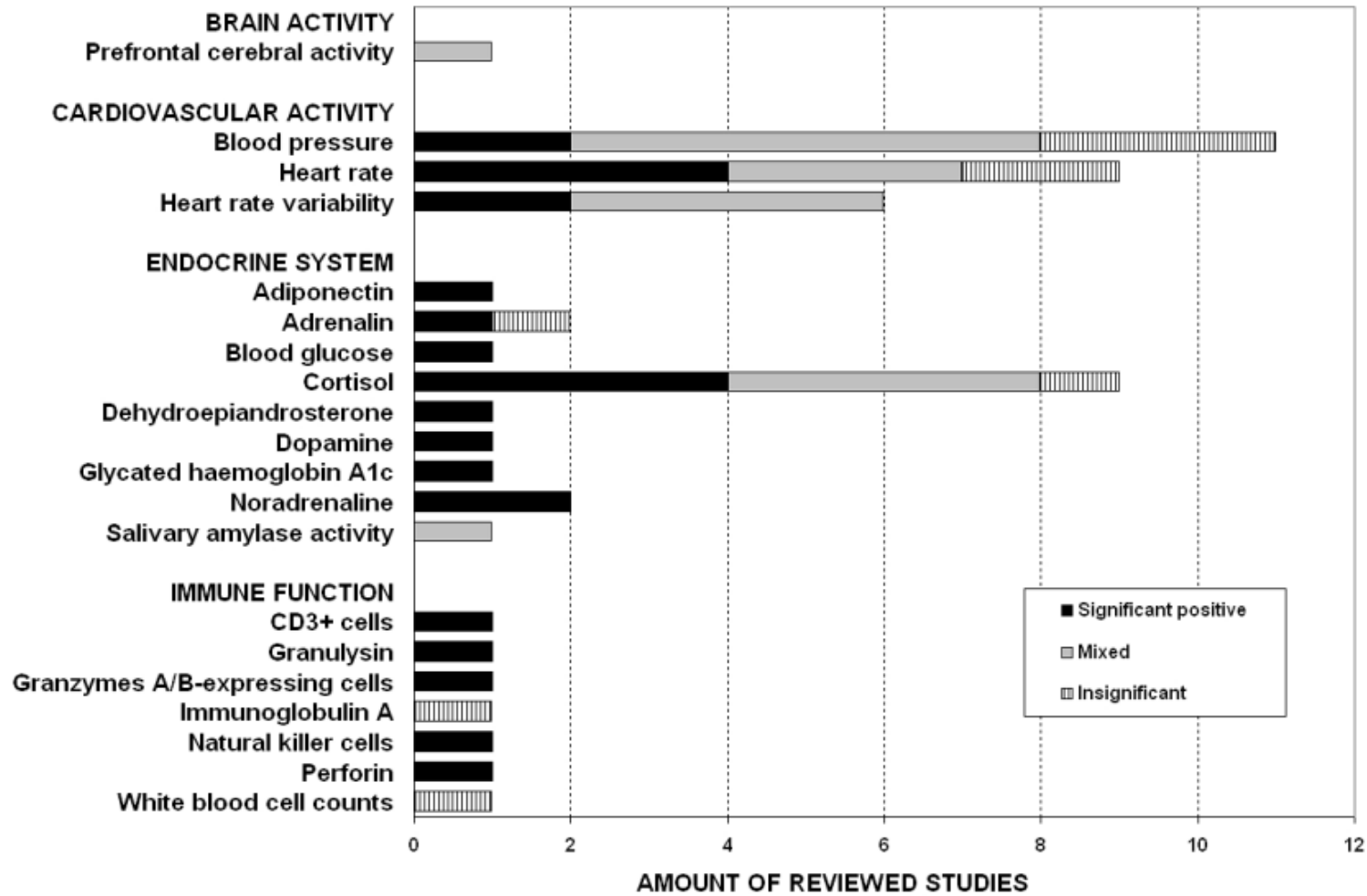


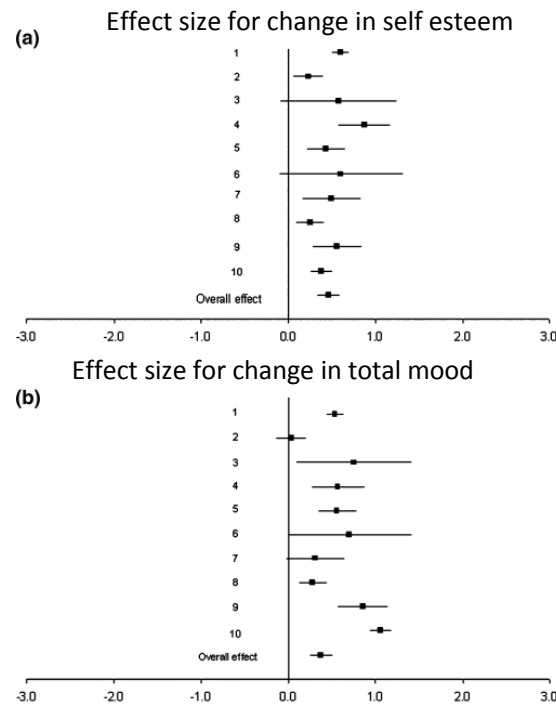
Figure 1. Study outcomes stratified by amount of studies (total n = 17) and physiological parameters

Haluza, D., Schönbauer, R., & Cervinka, R. (2014). Green Perspectives for Public Health: A Narrative Review on the Physiological Effects of Experiencing Outdoor Nature. *International Journal of Environmental Research and Public Health*, 11(5), 5445–5461. doi:10.3390/ijerph110505445

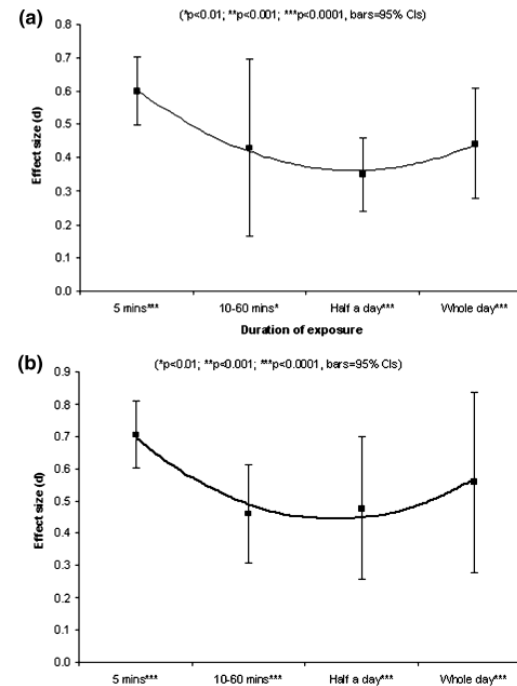
What is the Best Dose of Nature and Green Exercise* for Improving Mental Health?

Sample and method: meta-analysis of 10 UK studies involving 1252 participants using identical measurements

Results: Dose responses for both intensity and duration showed large benefits from short engagements in green exercise, and then diminishing but still positive returns. Every green environment improved both self-esteem and mood; the presence of water generated greater effects. Both men and women had similar improvements

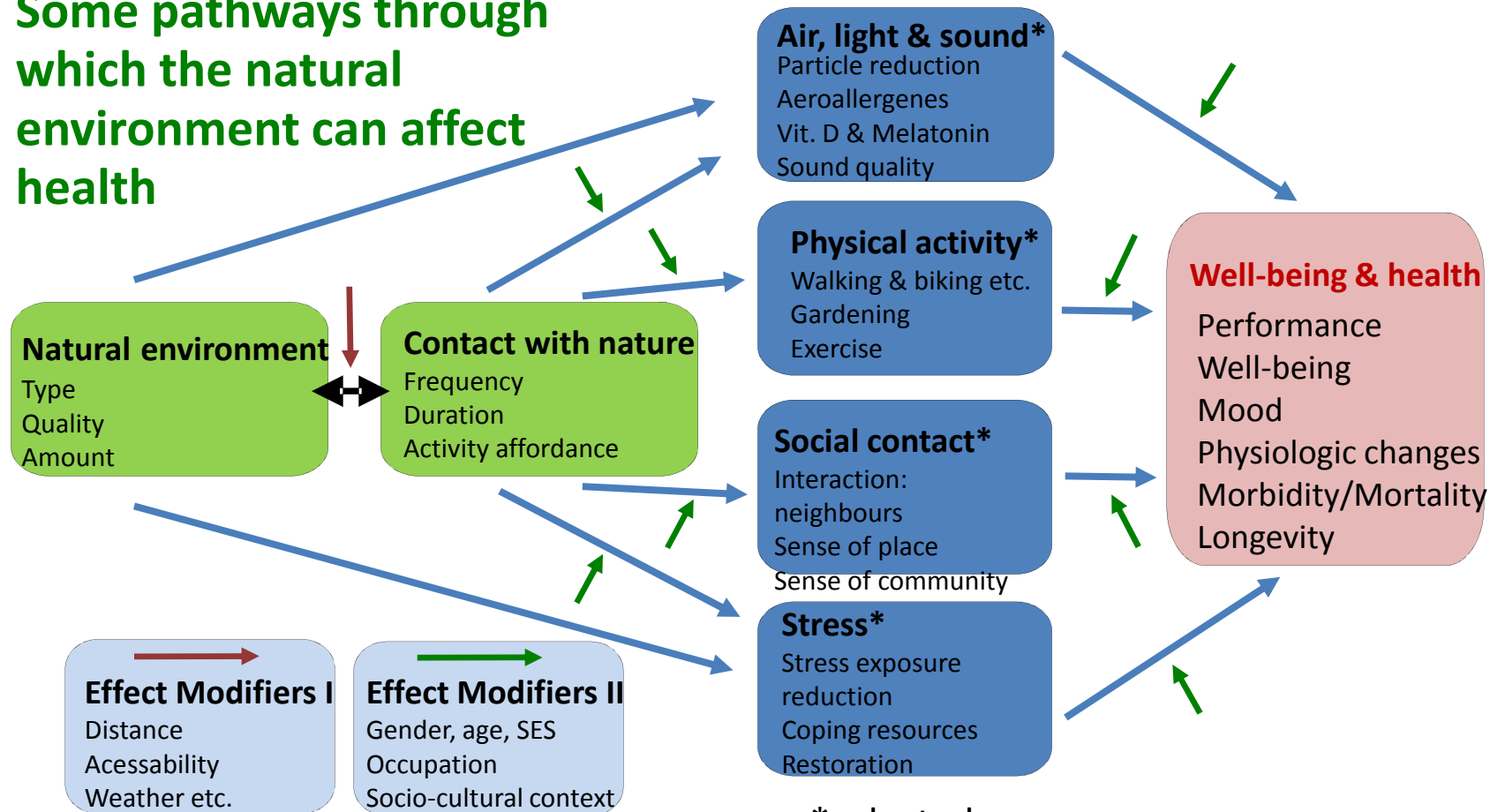


Effect size: differences between the pre and postintervention scores



* Different activities in nature: walking, cycling, gardening, fishing, boat riding etc.

Some pathways through which the natural environment can affect health



*selected examples

Slightly modified after Hartig et al. 2014

Measurement of restoration

- The **Perceived restorativeness scale (PRS)** by Hartig et al. 1997
 - Originally it intended to measure four elements of the Attention Restoration Theory (ART: Kaplan, 1995)
 - „being away“ & „fascination“: most consistent dimensions
 - „compatibility“: probably not an extra factor
 - „extent“: eventually consisting of „coherence“ and „scope“
 - 26 items with high Alpha value (>.90)
- As shorter PRS-scale by Pasini M. et al. 2014

Fascination

Places like that are fascinating (FA 12)*
In places like this my attention is drawn to many interesting things (FA 7)
In places like this it is hard to be bored (FA 11)

Coherence

There is a clear order in the physical arrangement of places like this (COH 15 Rev)*
In places like this it is easy to see how things are organised (COH 26)
In places like this everything seems to have its proper place (new item)

Being Away

Places like that are a refuge from nuisances (B-A 1) *
To get away from things that usually demand my attention I like to go to places like this (B-A 5)
To stop thinking about the things that I must get done I like to go to places like this (B-A 4)

Scope

That place is large enough to allow exploration in many directions (FA 10) *
In places like that there are few boundaries to limit my possibility for moving about (new item)
**Numbers in brackets are the item numbers of the original PRS-scale from Hartig et al 1997*

Nature-design relationships in the built environment*

■ Nature in the Space

- Visual connection with nature
- Non-visual connection with nature
- Non-rhythmic sensory stimuli
- Access to thermal and airflow variability
- Presence of water
- Dynamic and diffuse light
- Connection with natural systems

■ Natural Analogues (objects, materials, colors, shapes, patterns and algorithms that evoke nature)

- Biomorphic forms and patterns
- Material connection with nature
- Complexity and order

■ Nature of the Space (spatial configurations and associated psychological and physiological responses)

- Prospect
- Refuge
- Mystery
- Risk/Peril

*Source: Cramer, J. S., & Browning, W. D. (2008). Transforming Building Practices Through Biophilic Design (pp335–346). In S. F. Kellert, J. H. Heerwagen, & M. L. Mador (Eds.), Biophilic Design. Hoboken, NJ: Wiley.

Conclusions from a nature design perspective

■ Visual connections with nature

- Prioritize real nature over simulated nature, which is better than no nature (Kahn et al., 2008)
- Prioritize biodiversity over acreage (Fuller et al., 2007)
- Prioritize or enable exercise opportunities that are in proximity to green space (Barton & Pretty, 2010)
- Support exposure to nature for at least 5-20 minutes per day (Tsunetsugu et al. 2013; Barton & Pretty 2010)

■ Non-visual connection with nature

- Prioritize nature sounds over urban sounds to engender physiological and psychological restoration (Alvarsson et al. 2010).
- Use moderate ambient noise based on nature sounds to enhance creative performance (Mehta et al. 2012).
- Design for visual and non-visual connections with nature to be experienced simultaneously (Hunter et al. 2010).

■ Presence of water

- Water should be perceived as clean (Orians and Heerwagen, 1992).
- Prioritize a multi-sensory water experience (Alvarsson et al. 2010; Hunter et al. 2010; Pheasant et al. 2010).
- Prioritize naturally fluctuating water movement over predictable movement or stagnancy (Alvarsson et al. 2010; Biederman & Vessel, 2006).

Source: Ryan, C. O., Browning, W. D., Clancy, J. O., Andrews, S. L., & Kallianpurkar, N. B. (2014). BIOPHILIC DESIGN PATTERNS: Emerging Nature-Based Parameters for Health and Well-Being in the Built Environment. *International Journal of Architectural Research: ArchNet-IJAR*, 8(2), 62–76.

Conclusions from a nature design perspective

■ Access to thermal and airflow variability

- Incorporate airflow and thermal variability to improve user comfort a positive health impact (Wigö, 2005)
- Temporal and spatial alliesthesia – conditioning the individual (e.g, hands, feet) rather than the space for achieving thermal comfort and satisfaction (Parkinson et al., 2015; de Dear 2011; Zhang et al., 2010; Arens et al., 2006; Zhang, 2003; de Dear & Brager, 2002; Mower, 1976).
- Provide features that allow users to easily adapt and modify their perceived thermal conditions of their environment will increase the range of acceptable temperatures by two degrees Celsius above and below the conventional parameters for thermal comfort (Nicol & Humphreys, 2002).
- Perceived air quality is seen to be closely correlated to thermal comfort rather than to temperature (Zhang et al., 2011)

■ Complexity and order

- Fractal structures with iterations of three will be more impactful than a limiting design to two iterations (e.g., Salingaros, 2012).
- Fractal geometries with a mid-range dimensional ratio (broadly speaking, $D=1.3-1.8$) are generated in nature with relative profundity and should be more readily applied to architecture and design.
- Use fractal geometries in artwork (from realism to abstract); in building materials (e.g., wood grain, stone) for exposed structure elements, interior finishes, or components of the façade; in the building skyline; and in species selection for landscape views (Joye, 2007; S. Kaplan, 1988).
- Establish a balance between complexity and order (Kellert, 2008).

Source: Ryan, C. O., Browning, W. D., Clancy, J. O., Andrews, S. L., & Kallianpurkar, N. B. (2014). BIOPHILIC DESIGN PATTERNS: Emerging Nature-Based Parameters for Health and Well-Being in the Built Environment. *International Journal of Architectural Research: ArchNet-IJAR*, 8(2), 62–76.

Conclusions from a nature design perspective

- **Dynamic and diffuse light** (providing variability in light and shadows)
 - Shortage of light is in effect at least partially responsible for the emergence of a condition labeled Seasonal Affective Disorder (SAD; Rosenthal et al., 1984)
 - Positive impact on mood and self-esteem occurs most significantly in the first 5 minutes of exercise within a green space (Barton and Pretty, 2010)
 - Effective treatments for SAD today is optimally timed exposure to bright light (Terman & Terman, 2005)
 - Higher light levels have been associated with better mood (Kaida et al., 2007; Kööts et al., 2011; Partonen & Lönnqvist, 2000; Aan Het Rot et al., 2008) and being exposed to bright light during cognitive performance influences thalamic activity (fMRI study by Vandewalle et al., 2009)
 - Both bright light and natural environments have been found to increase vitality (Ryan et al., 2009; Partonen & Lönnqvist, 2000)

- **Prospect:** Is a spatial condition characterized by the presence of an unimpeded view over a distance for surveillance and planning. The PROSPECT pattern is mainly derived from visual preference research and spatial habitat responses
 - Prioritize real nature over simulated nature, which is better than no nature (Kahn et al., 2008)
 - Prioritize biodiversity over acreage (Fuller et al., 2007)
 - Prioritize or enable exercise opportunities that are in proximity to green space (Barton & Pretty, 2010)
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Source: Ryan, C. O., Browning, W. D., Clancy, J. O., Andrews, S. L., & Kallianpurkar, N. B. (2014). BIOPHILIC DESIGN PATTERNS: Emerging Nature-Based Parameters for Health and Well-Being in the Built Environment. *International Journal of Architectural Research: ArchNet-IJAR*, 8(2), 62–76.

Final questions to be asked

- What about frequency and duration of experience necessary to observe effects?
- How long are the health responses persistent?
 - Most evidence is from short-term experiments and cross-sectional studies
 - Longitudinal studies are needed
- What scale of intervention needs to be done to engender an adequate positive health response
- What do you gain from integration of the various stimuli („multisensory experience“? E.g. greens, water, sound etc.