# Senses & Sensibility'21

*Designing Next Genera(c)tions*

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# Senses & Sensibility '21: Designing Next Genera(c)tions

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Annalisa Di Roma

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*Senses & Sensibility: Designing Next Genera(c)tions*
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## Track 3
## Design for Health & Wellbeing

# A Beautiful Light.
## Fascination Against Depletion

**Martina Frattura**, **Massimiliano Mancini Tortora**, **Eduardo José Gonçalves**[a] and **Natalia Olszewska**[b]

[a] UNIDCOM/IADE, Unidade de Investigação em Design e Comunicação, Av. D. Carlos I, 4, 1200-649 Lisbon, Portugal

[b] University IUAV, NAAD Master, Venice, Italy

A study investigating the connection between the personal idea of beauty and the soft fascination phenomenon demonstrates that beauty can be beneficial to our mental health and well-being, as well as it seems possible to categorise some patterns crossing different cultures and countries. An experimental approach has been applied to the analysis of the individuals' beauty experience. When compared to the Goal-Directed Attention task, beauty contemplation may induce higher temporal beta power asymmetry and higher frontal alpha power asymmetry, which was demonstrated to be a signal of Vagus Nerve stimulation (VNS). We considered potential climate and culture bias in study design and conducted research across Europe, Canada, and Turkey, to gather quantitative data and look for a trend in the physiological response of people to beauty. In this study, the experimental approach had the objective to apply electroencephalography (EEG) and Galvanic Skin Response (GSR) as autonomic signal analysis to study responses to the personal idea of beauty. 154 individuals (87 women and 67 men) participated in the study, of which 137 were considered eligible. Participants were asked to: passively view 2 pictures, to look at their own beauty emblem for 5 minutes, and finally a fast recall test was performed, while an EEG per each moment and continuous GSR was recorded. Increased power in the asymmetry of the beta frequency band was found, possibly in relation to the viewings of the personal beauty emblem. The findings suggest that being exposed to an object representing the subjective idea of beauty could be linked with the involuntary attention mechanism, which is compatible with a positive emotional state.

Keywords *Aesthetics*, *Soft-Fascination*, *Restoration*, *Attention*, *Lighting*.

## Introduction

In the world governed by technology, people are requested to be resourceful, social, and attentive, and incorporate a wide array of environmental cues exerting their full cognitive processes activated (Bargh, Morsella, 2008). The spaces we inhabit can either leave us feeling depleted, or recharged: the environmental cues often contribute to our cognitive overload.
In environmental psychology the word “restoration” is used to describe an automatic (Kaplan & Kaplan, 1989) recovery of attentional resources, in response to environmental cues present predominantly in natural settings. Furthermore, Attention Restoration Theory (ART) (Kaplan et al., 2001) implies that it is beneficial to seek out environments that support regeneration of directed attention, a finite resource exerted whenever we aim to stay focused and effective.
In the lighting field, the topic of Human Centric Lighting describes the use of artificial lighting sources to create visual environments that mimic the natural one. As a matter of fact, light, both natural and artificial, is a physical stimulus capable of producing visual and non-visual responses. The non-visual effects of light cover the phase shifting effects of the circadian rhythm, as well lighting impact on instantaneous changes in our physiology, alertness, performance, and mood (Campbell et al. 1995). Recent studies have confirmed that all the types of photoreceptors (Rods, Cones and ipRGCs) contribute to both visual and non-visual responses, to some degree (Esposito & Houser, 2019). In fact, ipRGCs incorporate input from the Rods and Cones, creating parallelism in terms of visual comfort, visual acuity and non-image forming effects (Schroeder, et al., 2018).
In recent years, the need of designing beyond the mandatory standards, while respecting the permeability between human beings and the spaces they are at, has paved the path for new approaches for both designers and scientists.
Interdisciplinary approach has been required. Lighting designers started to focus on both visual and non-visual comfort and visual experience through implementation of rigorous scientific evidence that falls under the current knowledge on the complex effects of light on humans (Schlangen, 2019).
Psychologists began to investigate natural spaces and search for clues that could help with avoidance of the excessive stimulation (van den Berg, et al., 2003).
It follows that one of the challenges of this study is to merge the current research findings of these two disciplines, and to transform it into a valuable design tool.


Bargh, J. A., Morsella, E. (2008). *The Unconscious Mind. Perspectives on Psychological Science*, 3(1), 73–79.

Kaplan, R., Kaplan, S. (1989). *The Experience of Nature: A Psychological Perspective*. Cambridge University Press, New York. Republished, 1995. Ulrich's, Ann Arbor.

Campbell, S. S., Terman, M., Lewy, A. J., et al. (1995). *Light Treatment for Sleep Disorders: Consensus Report: V. Age-Related Disturbances*. Journal of Biological Rhythms, 10(2), 151–154.

Esposito, T., Houser, K. (2019). *A new measure of colour discrimination for LEDs and other light sources*. Lighting Research & Technology, 51(1), 5-23.

Houser, K., Boyce, P., Zeitzer, J., Herf, M. (2021). *Human-centric lighting: Myth, magic or metaphor?* Lighting Research &Technology, 53(2), 97–118.

Schroeder, M.M., Harrison, K.R., Jaeckel, E.R., et al. (2018). *The Roles of Rods, Cones, and Melanopsin in Photoresponses of M4 Intrinsically Photosensitive Retinal Ganglion Cells (ipRGCs) and Optokinetic Visual Behavior*. Front Cell Neurosci. 12;12:203.

Schlangen, L. J., (2019). *CIE position statement on non-visual effects of light: recommending proper light at the proper time*.

Van den Berg A.E., Koole S.L., Van der Wulp N.Y., (2003). *Environmental preference and restoration: (How) are they related?*, Journal of Environmental Psychology, 23(2), 135-146,

Kort, de, Y. A. W., Veitch, J. A. (2014). *From blind spot into the spotlight*. Journal of Environmental Psychology, 39, 14.

Kaplan, R., Kaplan, S. (1989), *op. cit*.

Haga, A., Halin, N., Holmgren, M., Sörqvist, P. (2016). *Psychological Restoration Can Depend on Stimulus-Source Attribution: A Challenge for the Evolutionary Account?* Frontiers in Psychology.

Yantis, Steven. (2008).*The Neural Basis of Selective Attention. Cortical Sources and Targets of Attentional Modulation*.

Itti L, Koch C. (2000). *A saliency-based search mechanism for overt and covert shifts of visual attention*. Vision Research, 40(10–12), 1489-1506.


Since we spend most of the time in a built environment, often in an attempt to meet the pressures of the workplace, investigation of the restorative potential of indoor spaces becomes an important research avenue. For example, in the context of the workplace, it is advised to have periodic breaks at the workstation (Tyler, Burns, 2008), and to seek exposure to daylight (Smolders, deKort, 2014). However, more research is required to understand how a built environment can provide restorative experience and mimic the innate restorative potential of nature.
A key environmental psychology concept relevant to this study, is “soft fascination” phenomenon, identified as one of the four characteristics of an environment that aids restoration of a fatigued mind. ‘Soft fascination’ was previously described as an ability of the environment or an object to capture attention in a subtle and effortless way (Kaplan & Kaplan, 1989). According to ART, visiting or viewing natural environments can have restorative psychological effects, while exposure to the built environment typically has fewer positive effects (Haga et al. 2016).
Neuroscience explains selective attention as per the process of focusing on a particular object in the environment for a certain period of time. This kind of attention allows us to tune out unimportant details and focus on what matters.
This perceptual selection could be achieved in two ways: bottom-up, involuntary, and stimulus-driven, depending on a stimulus salience, and top-down, based on the organism's behavioural goals (Yantis, 2008).
Physical salience, proposed as a mechanism of bottom-up attention, implies that objects, that are for example characterised by unique colour or motion characteristics, express high contrast which permits them to compete more effectively with other stimuli. This model of stimulus-driven capture of attention stresses the importance of local feature contrast in guiding attention (Itti & Koch, 2000). Top-down attention refers to the voluntary allocation of attention to certain features, objects, or regions in space (Pinto, et al., 2013).
Attention restoration, and soft fascination, have been previously linked with 'stimulus driven attention', and the so-called bottom- up attentional mechanism (Kardan et al. 2015), (Olszewska-Guizzo et al. 2018).
To observe neural correlates of fascination related to stimuli driven attention and to systematise physical attributes of restorative environments, we focus on recent studies that suggest that alpha and beta asymmetry between right and left

hemispheres can be valid biomarkers of attention restoration (Olszewska-Guizzo et al.,2018).
In this study, we investigate both ascending (bottom-up) and descending (top-down) attentional mechanisms: when subjects are asked to look at the image, they perform a task and voluntarily allocate attention to images (top-down), however we hypothesise that subjects' own beauty emblems capture their attention in an involuntary manner because of physical salience (bottom-up), and their associations (top-down). It was proposed that such personal associations can have additional impact on perceived restorative potential (Ratcliffe et al, 2016) and that increased beta activity over the right hemisphere correlates with attention restoration. Additionally, we consider frontal alpha asymmetry to be linked with emotion related symptoms, that is increased parasympathetic activation (Sun et al., 2017), which could be reflected by the low galvanic skin response (GSR) trend.
The greater objective of this investigation is to establish a link between the 'soft-fascination' phenomenon and artificial lighting, and an attempt to recreate outdoors' restorative potential in the context of the built environment.
In this article, the first of two experiments, is described, and it entails two hypotheses: that the 'soft fascination' phenomenon could be reproduced indoors and, secondly, that it could be linked to subjective beauty perception.
The parallelism between fascination and beauty follows the ability of the latter to have an impact on attention and motivational state.
For example, research demonstrates that beauty is highly adaptive, and the brain has evolved to activate neural networks associated with reward in response to beautiful faces (Lindell & Lindell, 2014).
We hypothesise this same that exposure to the personal idea/ concept of beauty may involve involuntary and effortless attention. This research project's vision is about bringing the fascination moment indoors.

## Methods

A study to test the hypothesis about the relationship between individual perception of beauty and soft fascination has been conducted. Individual beauty perception may vary according to the season, latitude, and cultural backgrounds. In the view of this, the experiment was designed to go over the most recurrent biases in the cognitive processes: culture and climate.
Ten cities spread in nine different countries at different latitudes were selected to host the experiment sessions: Calgary, Canada; Athens, Greece; Reykjavik, Iceland; Rome and Pescara, Italy; Lisbon, Portugal; Madrid, Spain; Stockholm, Sweden; Istanbul, Turkey; Manchester, UK. Data gathering took place in a different room for each location, while following four basic parameters: minimum size five square metres maximum ten square metres; a minimum of one daylight opening; plain and white or light-coloured walls; artificial light off.
With attention being the domain' study, we evaluated the impact of biological body rhythm, which places the high alertness moment before noon (Matchock et al., 2009) which led to setting the experiment hours from early morning to lunch time, reflecting each country's custom.

Pinto Y., van der Leij A.R., Sligte I.G., Lamme V.A.F., (2013). Scholte S.H.; *Bottom-up and top-down attention are independent*. Journal of Vision; 13(3):16.

Kardan, O., Demiralp, E., Hout, M.C., Hunter, M.C., Karimi, H., Yourganov, G., Jonides, J., Berman, M.G. (2015). *Is the preference of natural versus man-made scenes driven by bottom–up processing of the visual features of nature?* Front. Psychol.

Olszewska-Guizzo, A., Paiva, T. O., Barbosa,F., (2018). *Effects of 3D Contemplative Landscape Videos on Brain Activity in a Passive Exposure* EEG Experiment. Frontiers in Psychiatry, 9, 317.

Ratcliffe, E., Gatersleben, B., Sowden, P. T., (2016). *Associations with bird sounds: How do they relate to perceived restorative potential?* Journal of Environmental Psychology, 47, 136-144.

Sun L., Peräkylä J., Hartikainen K.M., (2017). *Frontal Alpha Asymmetry, a Potential Biomarker for the Effect of Neuromodulation on Brain's Affective Circuitry—Preliminary Evidence from a Deep Brain Stimulation Study*. Frontiers in Human Neuroscience. 11, 584.

Lindell A.K., Lindell K.L., (2014). *Beauty captures the attention of the beholder*, Journal of Cognitive Psychology, 26:7, 768-780.

Matchock, R.L., Toby Mordkoff, J. (2009). *Chronotype and time-of-day influences on the alerting, orienting, and executive components of attention*. Exp Brain Res 192, 189–198.

*Participants*
A total of 154 participants were recruited among students and professionals, between 20 and 40 years old.
The following numbers of men and women were recruited in each city: Athens 3-8; Calgary 11-10; Istanbul 7-7; Lisbon 8-8; Madrid 2-11; Manchester 7-9; Pescara 10-12; Reykjavik 4-7; Rome 6-8; Stockholm 8-8. Seventeen people were excluded from the study because of the quality of the recording and or because of lack of full test completion. All selected participants had normal, or corrected to normal, vision. All participants signed the informed consent form and filled in a beauty-related qualitative questionnaire.

*Stimuli*
The test was divided in three moments, reflected by three different stimuli.
First one was a presentation of two images whose selection was inspired by the IAPS standardised set of pictures' method: picture of a vegetable; picture of a child.
Second moment was based on the beauty emblem the participants were asked to carry with them. The requirements indicated a visual element (e.g., An object, a picture of a person, a postcard of a town, etc.), no additional restrictions were provided.
At the third moment a list of 10 letters was presented on a screen, one at a time, randomly generated by a software.

*EEG and ECG Apparatus*
Subjective assessment of emotional valence is typically associated with both brain activity and autonomic arousal (Farrow at al., 2013). Quantitative data have been gathered in the quasi-experiment in nine different countries with an EEG

instrument to monitor the brain electrical activity and an EDA to track the galvanic skin response (GSR).
The EEG data acquisition was done with an Emotiv EPOC ® EEG Headset (Emotiv Epoc, San Francisco, CA, USA) consisting of a wireless headset of 14 channels for EEG signals + 2 channels as reference points, with a sampling frequency of 128 samples per second. The EDA data acquisition was done with eSense Skin Response (Mindfield®, Gronau, Germany) eSense equipped with two gel electrodes per participant.

*Data collection*
The 15 minutes attention test was divided into three different moments. Participants were initially told not to drink any caffeine-based drinks for two hours prior to the experiment and they were asked to bring an object representing their own idea of beauty with them.
Volunteers were seated and, following the wearing of the equipment, they were instructed to minimise movement during the test for a better-quality recording.

Moment 1 – Looking at two images for a minute in total. Participants were asked to look at two pre-selected pictures on the screen for a minute in total, 30 seconds each picture. The attention domain of this test is selective attention, as per the process of focusing on a particular object in the environment for a certain period of time.

Moment 2 – Looking at their own beauty emblem for 5 minutes. Participants were asked to carry with them a symbol of their own idea of beauty. The second moment of the test was to look at their beauty emblem, to test the hypothesis that beauty perception can be linked with the phenomenon of Soft-fascination, one of the four characteristics of an environment that help to restore a fatigued mind (Kaplan & Kaplan, 1989).

Moment 3 – Fast recall test. Participants were asked to look at a screen where a list of 10 letters was presented, one at a time, and their task was to remember as many of the letters as possible. As per moment 1 of the test, we are considering the selective attention, but with a dominance of top-down mechanisms, as per attentional selectivity is proven to be linked with working memory processes, as per the recall test. In the view of this, tracking this test's results was not the objective, but the act of trying to recall the letters.

Farrow T., Johnson N., Hunter M., Barker A., Wilkinson I., Woodruff P., (2013). *Neural correlates of the behavioral-autonomic interaction response to potentially threatening stimuli.* Frontiers in Human Neuroscience. 6, 349.

Kaplan, R., Kaplan, S. (1989), *op. cit.*

*Data Processing and Analysis*
The EEG Raw Data package was about 470 EDF files, from 80 to 300 seconds trials.
Data analysis was performed using Jupyter Notebook coding with python and specific open-source python package for exploring, visualising, and analysing human neurophysiological data. All the raw edf files were flat without annotations for bad channels or bad time span. Moreover, the data structure should be considered flat as there were no epochs, periods, events registration during the recordings.
The EEG basic pre-processing has been relevant to the manual detection of bad channels and of bad time spans. No artefacts removal has been considered useful for the purpose of this paper.
Data analysis is focused on the study within the two main frequency bands:  Alpha (7.5-14 Hz) and Beta (14-30 Hz).
With collecting and analysing these data, we are assessing the ability of subjective perception of beauty with capturing attention and altering attentional deployment rapidly and effortlessly. Because of this, we checked the frontal alpha asymmetry temporal beta asymmetry. According to the EMOTIV hardware model, the electrodes of interest are (frontal) FC5, F7, F3, AF3 - FC6, F8, F4, AF4 and (temporal) T7, T8.
The recorded EEG data have been re-referenced to the average of all the electrodes before the processing.
Data has been then filtered for slow-drifts removal (low-frequency <1Hz) and a notch filter has been applied for power noise attenuation at 50 Hz.
A reference period of 10 s has been selected for Moment 1 and Moment 3.
Moment 2 was segmented in 10 second epochs for the analysis.
Band pass filters have been applied to extract the Alpha and Beta frequencies of interest.
As a result, we obtained two files per subject and per single moment, each containing one of the frequencies described above. The mean absolute power was computed for each electrode as the average of the square voltage amplitude at each time point (μV2).
Power values were log transformed to normalise their distributions, and asymmetries between brain hemispheres per EEG band were computed by applying the formula (log(R)-log(L))/(log(R)+log(L)), where R is the power of a particular EEG band on the right hemisphere and L is the power on the left hemisphere (Davidson, 1988).

Frontal Asymmetry for Alpha band and Temporal Asymmetry for Beta band have been investigated.
It is considered no-asymmetry when the relation between left and right power is equal to zero, while it is a considerable presence of asymmetry when there is a higher activity of the right hemisphere over the left one (Baehr et al., 1999).
The asymmetry between right and left hemisphere for alpha and beta frequency bands at the frontal and temporal electrode locations was checked on the total group and on each individual nation.

*Correlation Analysis*
We hypothesised that the experience of beauty, related to the 'soft fascination' phenomenon, would induce higher frontal alpha power asymmetry and higher temporal beta power asymmetry, when compared to selective attention moments.
Comparing frontal alpha asymmetry scores in the context of neutral stimuli (BL) from frontal alpha asymmetry scores in the context of beauty-related stimuli gives an index for the impact of the exposure to the personal idea of beauty on alpha asymmetry.
Similarly, comparing temporal beta may suggest the existence of the relation between beauty and soft fascination.
After deriving these measures for each moment of the experiment (i.e., Moment 1, Moment 2, Moment 3) separately, we expected to find an increased asymmetry in Moment 2, resulting in an association of beauty with positive emotion-related states. It followed a correlation analysis where we look at changes in skin conductivity on beauty exposure linked to stress decrease.

## Results

*Biomarker A - Higher Frontal Alpha Asymmetry*
No significant asymmetry was shown in Moment 1 and Moment 3, which is reflected by values close to or equal to zero for the selected time segment. Analysing the entirety of the Moment 2 per participant, we see no significant correspondence between being exposed to the personal idea of beauty and an increased frontal alpha asymmetry.
The subgroups show that 3 out of 10 cities had an inverse trend - decreasing asymmetry - (Fig. 1), which results in 33.6% of the population not matching the hypothesis.

*Biomarker B - Higher Temporal Beta Asymmetry*
No significant asymmetry was shown in Moment 1 and Moment 3, which is reflected by values close to or equal

Davidson RJ. (1988). *EEG measures of cerebral asymmetry: conceptual and methodological issues.* Int J Neurosci. Mar;39(1-2):71-89.

Baehr E., Rosenfeld J.P., Baehr R., Earnest C., (1999). *Clinical Use of an Alpha Asymmetry Neurofeedback Protocol in the Treatment of Mood Disorders.*Introduction to Quantitative EEG and Neurofeedback, Academic Press, 181-201.

Fink G.R., Halligan P.W., Marshall J.C., Frith C.D., Frackowiak R.S., Dolan R.J., (1997). *Neural mechanisms involved in the processing of global and local aspects of hierarchically organized visual stimuli.* Brain, 120(10), 1779-1791.

Hopman, R.J., LoTemplio, S.B., Scott, E.E. et al. (2020) *Resting-state posterior alpha power changes with prolonged exposure in a natural environment.* Cogn.Research 5, 51.

Kaplan, S., & Berman, M. G. (2010). *Directed Attention as a Common Resource for Executive Functioning and Self-Regulation.* Perspectives on Psychological Science, 5(1), 43–57.





to zero for the selected time segment. Analysing the entirety of the Moment 2 per participant, we see possible correspondence between being exposed to the personal idea of beauty and a higher temporal beta asymmetry.
The subgroups show that 1 out of 10 cities had an inverse trend - decreasing asymmetry - (Fig. 2), which results in 92% of the population matching the hypothesis.

*Biomarker C - GSR*
No significant evidence to suggest a link between Moment 2 and activation of the Parasympathetic system, on the GSR value. On the contrary, four out of ten subgroups show an increase of skin conductance, possibly attributable to a higher stress level (Fig. 3).

## Discussion and future directions

We studied how the personal idea of beauty could possibly modulates emotional processing and attentional mechanisms by analysing changes in emotion and attention-restoration related alpha and beta asymmetry,
together with the observation of the autonomic response via skin conductance.
Our hypotheses regarding frontal alpha power asymmetry and galvanic skin response were not confirmed, which invites further research in this direction, also with the evaluation of other experimental settings.
The results revealed one main finding that could support one of the hypotheses: greater beta power asymmetry, possibly directly related to the exposure to beauty.
Looking at a beauty emblem when compared to other selective attention tasks could be linked to the activation of the right temporal areas of the brain. This pattern could be associated with bottom-up, stimuli driven attention directed at the salient stimuli, which can be linked to attention restoration.
Visual information interpretation and global visual attention is in fact regulated by the right temporal areas of the brain (Fink et al., 1997), which could justify the impact of personal ideas of beauty on them.
Despite the high degree of subjectivity, the influence of aesthetics on brain and mental states could have benefits for the attempt of bridging the gap between natural and artificial environments, in terms of restorative cues.
In the lighting field, the topic of Human Centric Lighting, describing the use of artificial lighting sources to create visual environments that mimic the natural, has been presented already for several years.


Figure 1: Frontal Asymmetries, Mean 95% confidence interval.
**a** Athens **b** Calgary
**c** Instambul **d** Lisbon
**e** Madrid **f** Manchester
**g** Pescara **h** Reykjavik
**i** Rome **l** Stockholm


Figure 2: Temporal Beta Asymmetries, Mean 95% confidence interval.
**a** Athens **b** Calgary
**c** Instambul **d** Lisbon
**e** Madrid **f** Manchester
**g** Pescara **h** Reykjavik
**i** Rome **l** Stockholm

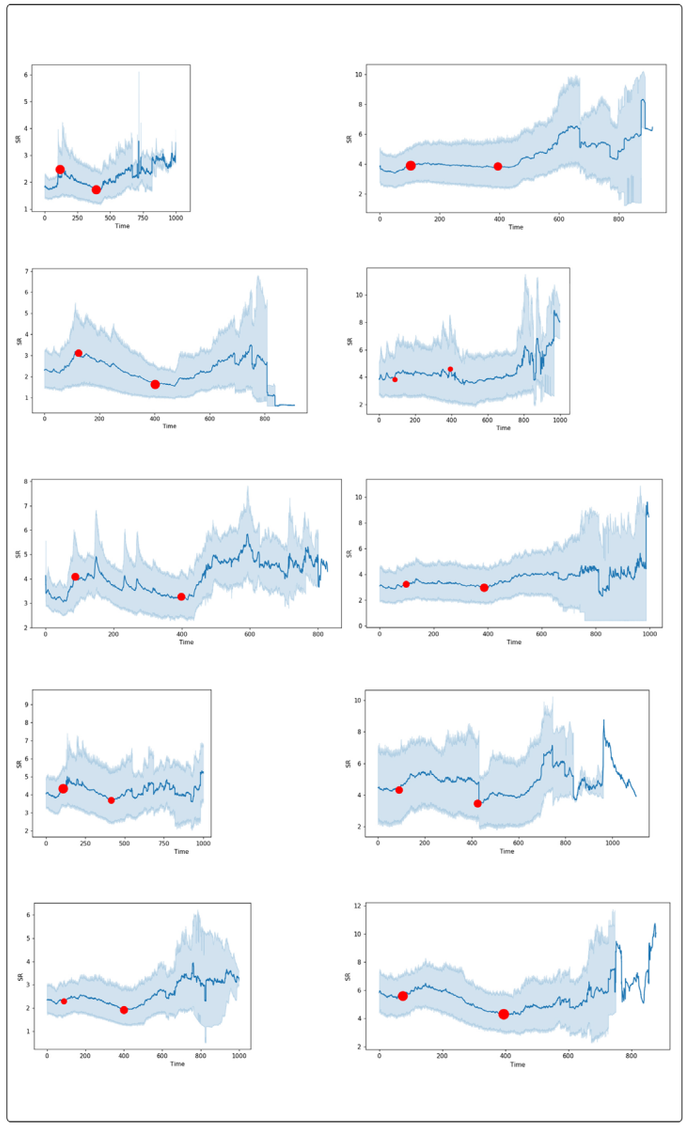

Figure 3: Galvanic Skin Response, Mean 95% confidence interval.
**a** Athens **b** Calgary
**c** Instambul **d** Lisbon
**e** Madrid **f** Manchester
**g** Pescara **h** Reykjavik
**i** Rome **l** Stockholm.

The next study wants to address attentional mechanisms, which fall into the non-circadian or acute non-image forming effects of light exposure. The aim is to individuate the lighting scenario that can contribute to the overall well- being of the people in a space, with maintaining the focus without depleting all the mental resources.
The presented study represents the first attempt to examine a possible relation between beauty and fascination. The overall research project intends to show evidence of indoor induced mental restoration while analysing the data gathered and will also give evidence of the positive impact of the light in the balance of the attention levels.

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