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Innovators in Healthcare Presentation

5 October 2024 online

Introduction

I would like to introduce some research we did here in Prague. When we want to talk about light, first, we need to know the characteristics of light. So as a light engineer, I always discuss, first, the quantity,

We have to think back in the nature light, on what our ancestors did. So, looking on prehistory, spending all day outside, in medieval, basically spending all day outside as well, working on the fields, at least here in central Europe.

Then came the industrial revolution, when we thanks to this artificial light using gas, we actually could move into inside into factories and the contact with daylight was suddenly much lower Which resulted in a trial of having some rules and control how much light we actually get inside buildings.

So beginning of 20th century, there were very strict rules, which actually based this modern architecture with big windows and control of how much daylight we get inside our residential or even working spaces. Which now at the moment, thanks to our technologies and using a lot of screen time and all the reflections and being afraid of glare and overheating, we close again and we limit the amount of daylight we have inside our buildings.

So we are getting slowly back into dark cave, which our body is not used to, or was not used to before. And when we look at some very simple figures of how

the day and night light quantity change across the time, you can see that this huge rhythm of bright light over daytime and darkness, deep darkness during the night is actually diminishing and the difference is very small, much smaller than it used to be. So that's good to keep in mind, but we are actually not living in a natural condition.

The second topic we always have to discuss with lighting, is spatial distribution. Originally, when we were outside, the light was coming from the sky, and at the moment, if we are very lucky, we have a big size window, but in many buildings, it's coming from a side, and it's not the whole sky, it's just from one side light. So there is a difference in the spatial distribution.

Next thing is the spectral composition of the light, which is changing in nature as well. We can have the sky with a lot of blue component in the Nordic sky, or even when you look on the blue sky with sunlight on the zenith, or you can have a sky with a lot of green colors in the evening looking to the setting sun, and it's changes in between.

And this is very important and it's very natural, and it's actually missing in electric lighting, quite often. So when we describe light, we always use spectral composition, spatial distribution, quantity of light. That's normal, but we need to add a frame within timing of the day because if you put the same light during the day or during the night, it has a very different effect.

So we need to change the light to have more dynamics, not the stable thing coming from early morning to the late evening, all the same. But the day and night changes are getting through our eyes, the signal is getting through our eyes to our brain where it's a synchronizing the internal biological clock and the information is going to all the cells of our body doing the same thing.

And that's very important for for many processes happening in our body. So this would be in nature, but unfortunately there is not always enough daylight in the places where we stay. And the question is whether it can be replaced with electric lighting. So I would like to show you some case studies.

Case Study 1: Residential Care

First of them is in senior residential residency in Czech Republic. It has been done in the beginning of 2020, which is actually the year of COVID when we started. Our subjects were very isolated. They were actually restricted to go outside, they had to stay inside, and in the moment we had our sensors and our

new lighting system installed, so we have to record before and after, and this data is coming from these very difficult times.

If you look on the original state, you can see there is not much of daylight, and there is actually not much electric lighting as well, and the quality of the spectra is very low. So this is not very positive news, but it's not an extraordinary condition.

It's what we see in majority of the places that we visit. Because we could not touch the electric installation, we had to replace the lighting at the same positions. We developed this lighting device where is actually intelligence because it knows the time of the day and the time of the year, and it provides the light during the day that is much brighter than the original one.

It's directed towards the ceiling. So it gives you the impression of a sky. And the picture is just a cell phone photo. In your naked eye, it would not appear as these white spots. It's really give you the full ceiling of light, which is not too bright to be glary, but it's bright enough to give you more than 500 lux on your retina when you are moving around the room. And look at the spectra, which is brilliant. It is almost balanced from all across the visual part of the spectra . In the evening the light goes low with the quantity of course, it changed the direction. It does not provide the bright sky anymore. And it limits the amount of blue. And it goes from I think 300 lux to as low as 40 or even lower, just before sleep time. And when you switch off the light there is still the potential night lighting, which is very low lighting level.

The light is positioned under the bed, so it's not going to the eye if you are staying in bed. It's not disturbing the neighbors. And it's just enough to walk around the room and not to hit any obstacles. You don't have to take care of switching or on or off because there is a sensor. So it goes automatically when you touch the floor, which is a huge thing because then our seniors do not have to take care of it at all. Of course, we cannot stay only in the bedroom, but we have to put the same system all around the building. So here you can see the changes in the corridor from original state to the new state, where there is way less light, but it's very nicely distributed, and again, it has no blue light in it.

The nurses, even the nurses can get adapted to this lower lighting level and they do not have to switch on the light in the bedrooms when they enter, which is very important because they visit some of the bedrooms several times at night. Same thing was done in the bathrooms where you have again, the daytime and the nighttime set up.

And for the nighttime you have a light without any blue and with very low quantity, but still enough to provide all the visual information needed.

If we make a comparison of all the lights and we recalculated this melanopic equivalent daylight illuminance, you can see that the original quantity of light would have about 130 lux at the eye of the person staying in bed. We now got the daytime 500 melanopic lux, and in the evening we get to something like 20, and during the night to as low as two lux, which is very low, but still providing the service we need.

We had the chance to collaborate with National Institute of Mental Health. So they did some tests and they collected the melatonin profiles. So if you look on the all participant melatonin profiles, you can see there is some more melatonin over the night, but what is significant is decrease of melatonin over the day, which is a very good message.

Individual profiles shows many changes and all of them are very positive. Either there was no effect before and suddenly after the intervention we got beautiful melatonin rhythm or there is the rhythm being more consolidated or shifted within the time or some of the other effects. So there are just three examples of the individual profiles that you can see. We collected as well the activity measurements. So here is the November before intervention. You can see that there is long activity till the late evening hours, which actually disappeared after the intervention in February. You can see very nicely consolidated day time rhythm with almost no activity in the night.

These are seniors, they have all troubles and they have all their sleeping troubles originally because of the age, so I would say this is a great message. We actually asked them as well for the subjective feedback and I was very happy to see that they were very satisfied with the safety of movement around the space after during the nighttime.

They really liked that fact that they don't have to take care of lighting and they can see what, where they're going.

Case Study 2: Intensive Care Unit

So next study, which I want to present is a study from intensive care unit, a cardio unit from one of the main hospitals in Prague, where we applied very similar concept.

So this is the daytime light. And you can see this is a very sophisticated, very controlled environment with all with many actions and setups that have to be followed. So we were very lucky to actually have chance to install light in here. So you can see here the daytime. You can see the nighttime where we provide very low lighting level, again, up to five lux maximum, but enough for the nurses. We have very good feedback from from the staff there. They are very happy with the lighting. And here you can see all the three conditions: we go slowly from the daylight to to the evening.

And then the night light after we switch off the evening light. You can see the spectra in there, of course, during the night, there is always the chance to switch on the system to get a powerful light to proceed all the needed actions at the moment. So there is a safety light to be able to switch on.

We don't have any results from that because it was only installed this January. So those tests are still being done, but we have very good feedback from the nurses from all the staff there.

The third study, is not focused on circadian stimulation or on sleep, but it's on mental health. It's something would be called light spa. It's placed in a mental health Institute in Czech Republic, close to Prague. And you can see, this is a light box where you can sit inside with your friends or you can fit there a group of up to six people.

You can have your morning chat or read your newspapers, if they are positive news, of course. And you can get your light therapy. You can see that there is a big sky. It's all a light source where we provide really high luminance and you get a lot of light in. We can get up to 12,000 lux on your eye when you sit in there.

But we don't go that high. We actually go to halfway, and it's still very powerful. It's very comfortable space because you can look directly into this light source: it seems as a sky, and as if you look towards the sky, it still is nice to watch. So your eyes won't hurt. It won't be disturbing. It's not glaring at all because of this big surface. The light spectra is a little bit manipulated: we have a lot of efficiency in this blue green region where the non visual system is sensitive. We actually lowered the part of the visual maximum sensitivity about 550 lux around because we didn't want to have the perception of such a bright light. We were afraid that the patients maybe feeling this is too bright for them. So that's why we manipulate the spectra a little bit. It stills fulfill all the requirements for regular light. So it has all the color rendering properties we need to have. It's very comfortable inside and actually our patients really like it to stay there in

the morning. We don't have to push them. We did several tests there. So if you look on the self assessment question, which is the positive negative affect schedule, we can see that there is a reduction in negative affect, both in sustained and acute exposure to the light.

And we did some EEG tests there as well. And we could see effects in the left insula, which is the part of brain, which is involved in processing emotions. So there is a slight decrease of negative emotions, of negative affect, which is really a nice message as well.

And it goes together with all the subjective and short term setups and tests we did in there. So if I would conclude this talk, I would say that light in our environment is a biologically active substance, and we should think about it and keep it in mind. The regular daily rhythm and synchronized internal biological clock are very important for many reasons.

For a good synchronization, it's essential to create a strong contrast between day with the light and the night with the darkness. If we talk about light environment inside buildings, we need to discuss Intensity, spectra, distribution in space and distribution in time, and we have to put all four of them to work with each other.

And these are my collaborators, so the University Center for Energy Efficient Buildings where I work. And the team from National Institute of Mental Health and the company SpectraSol, who are kind enough to make the light sources for us so we can actually do all these experiments. And all these studies were funded by the Technology Agency of Czech Republic.

And with that, I would like to thank you for the attention.

Shelley:

What material did you use for the diffuser?

Lenka Maierova:

It's actually a huge LED light source behind behind a flexible membrane. We tested several of membranes. We found one which is not affecting the spectra, or which is affecting the spectra very little.

I'm sorry, I don't know the name of the company, but it's commercial one. It's not anything special.

John Bullock:

I think when we're all approaching this with the same aim, and we're all finding our own little avenues and back lanes to get there. It's interesting how you get your diffused light during the day that sheer amount of illumination that you need to get into the eye, as to whether you do it directly straight off the diffusing face of the fixture, or whether you take the indirect light off a ceiling.

Lenka Maierova:

Yes, my preference would be the indirect always this membranes are made because of the setup because this unit could be transferred from one department to another. And we don't have space for that. If I could choose, I will always use the indirect light.

Thank you.