Interview with Dr Belal Abboushi

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Introduction

Belal is a senior associate lighting research engineer at the Pacific Northwest National Laboratory. Belal is involved with several projects, examining lighting, uniformity, discomfort glare, daylight integration and effects on occupants' comfort and wellbeing. Belal earned a PhD in architecture from the University of Oregon, where he was involved in studies investigating indoor environmental quality in buildings at the high performance environments lab. He presented his research in various venues, including the IES annual conference, LightFair and Greenbuild.

Q: How can bright light help you to sleep?

Belal: So I think with daylight, we often think about increased intensity, but I think there's other aspects too looking at spectrum temporal variation, as well as the spatial distribution of daylight over the course of the day, variations on all these four factors might affect sleep quality and alertness

Some studies suggest that the increase in illuminance at the eye could improve alertness and sleep quality specifically looking at sleep duration and, perhaps, reduced sleep disturbances at night. In two studies specifically over the course of a week, there was an improved or increased sleep duration of about 30 to 45 minutes between a group that had access to daylight and views and another group working solely under dim electric lighting conditions.

So I think the four factors, which are increased intensity, different spectrum variations and intensity over the course of the day, as well as the spatial distribution and directionality from daylight, all of those may affect sleep quality.

I think alertness is a really interesting aspect. Specifically it's not only that people perceive that they sleep better, but the improvements in the sleep might also tie to improvements in alertness the next day.

So people that sleep better might perform better the next day, might feel more alert, more rested. In some cases, increased illuminance at the eye might not necessarily tie to improvements in alertness.

So I think there are several factors there, but the important aspect I think here is that some studies found that increased illuminance at the eye might improve alertness; other studies did not find that conclusion.

I would like to highlight that there is an importance for the time of the day. As we all know, higher levels of 'cooler' light at night might not be the best idea for improvements in sleep quality. So, exposure for the right amount of light and the right spectrum at the right time of the day, might yield the best results for improvements in sleep.

So you mentioned four very particular things about daylight to do with brightness, the time of day angle. Is it possible for artificial light to come anywhere close to those qualities to support alertness and sleep?

I think there's definitely a lot of potential for electric lighting to support that independently or in integration with the daylight systems. We've seen a lot of studies that started to look at variations in spectrum over the course of the day to mimic changes in intensity.

But I think there's a lot of opportunities there for electric lighting systems to be more integrated with daylight systems to promote these benefits for sleep quality and alertness.

So is it possible to separate brightness from colour temperature in the effect on alertness?

Some studies have separated the impact of illuminance at the eye from the spectrum. But it's often the case that when we talk for example about daylight, those two change at the same time, changes in intensity come with changes in spectrum.

So maybe higher intensity comes with specific CCT that changes over the course of the day. What I mentioned 'earlier' that sometimes a higher intensity may not always be better is because people sitting closer to the window might get more illuminance at the eye compared to people sitting further inside the office. So those people very close to the window are being blasted by higher

illuminance at the eye and the electric light system might be disconnected from that.

And that's why I think that integration is really a key issue, to emphasize that people closer to the window don't necessarily have to be blasted with a lot of light. It has to be balanced.

We're also finding that people's view direction could also matter. People looking towards the window might experience higher brightness and a different spectral power distribution at their eye compared to people looking 45 degrees or 90 degrees to the left or to the right. So I think that's where we could separate brightness and spectral power distribution. But I think these are both tools that we can utilize to improve these outcomes.

I wonder if there's ever a trade off - like having a strong coffee or being really awake for an exam - whether there's ever a trade off between getting feeling really alert, in the morning, for example, and then having a crash or feeling more tired later on? Would that be the reason for conflicting results?

It might be the case that if we drain the body earlier in the day, people might tend to be tired later on. I am not aware of any studies that had looked at these trade-offs, but I think future studies would really be beneficial to tackle this point

It does seem as though there's a rush to more alertness, but perhaps there's only so much 'being alert' you can do in a day.

Mostly we look at alertness as something positive if we look at workspaces, sometimes maybe more alertness might not be preferred if we're looking at maybe residential spaces or before bedtime.

I've read about how brighter cool lights tends to induce alertness, but also that maybe warmer, softer light, even in the work environment, is conducive to more creative thinking, collaborative thinking. Have you come across that?

Even if you were looking at warmer light versus cooler light, there's still the question of intensity that could vary between the two settings. So there might be

some confounding variables there. But if we talk about alertness versus promoting collaborative work, we might not be able to both at the same time.

We might be able to find a solution that promotes collaborative work and promotes alertness and sleep and ticks all the boxes. But in some cases we might need to do a trade off between improvements on visual tasks but also ticks all the boxes in relation to the non-visual effects.

So would you say that there is a trade-off between an alert, focused feeling and a more relaxed, collaborative feeling?

They might not be a trade-off. I think more research is needed there. Hopefully it's not a tradeoff that we have to choose one or the other. Hopefully we can find synergies and we can promote both at the same time.

So you mentioned visual interest or luminance distribution as something that matters in daylight. Tell me what you should be looking for if you're designing a workspace, particularly: what is it about natural distribution?

We've done some studies where we've looked at the shape of the luminance patterns in a space. And we looked at the impact on visual interest. Those seem to have more of an impact in spaces that maybe don't have access to daylight.

But when we do have access to daylight, I think other aspects like view and access to daylight might be more important than the spatial distribution itself. That doesn't mean that it's not an important aspect. It just means like it's one piece in the puzzle. We also looked at the spatial distribution or luminance within the luminaire aperture itself.

In some studies, that was found to be related to effects on discomfort glare and satisfaction. So that eventually might tie to effects on mood or visual interest. So this really emphasizes the idea that when we look at the occupant in the space, we need to consider the impact on a wide range of outcomes, including the visual interest, on satisfaction, the visual effects and the non visual effects.

So it's a very complex topic. But as more research is done to disentangle this, we understand the direct effects and the interactions between these different factors more and more.

Ideally I think people would have access to daylight. But what we're seeing is that people closer to the window would have access to daylight. But as we move away from the windows, just maybe 10 feet or 15 feet, the amount of light drops.

So that's where we really have to rely on electric lighting systems to work together with daylight systems to maybe also create pleasant luminance patterns that not only satisfy visual tasks and provide enough illuminance at the eye or at their desk, but also to promote visual interest and other aspects like improvements in mood.

So is there a way to say this is the kind of luminance distribution, this is the kind of range of brightness in a space which will create that visual interest or improve mood?

We looked specifically at luminance pattern shapes and we found that those patterns that look closer to nature, like fractal patterns tend to be preferred over striped patterns. But again, that I think has to be taken within the context: what tasks are people doing? How much of their gaze is going to be towards those areas where those patterns in the space, are they sitting and lounging and just kind of enjoying the space or they actually have a task at hand with little interest and time to look at their surroundings.

So I don't think there's a one size fits all approach. It all depends on what task an occupant is doing, time of the day and other factors that could affect what luminance pattern might be preferred at a certain time. Some patterns might promote alertness more than others.

Some patterns might promote relaxation more than others. So for example, we looked at plotting different patterns on two axes where the X axis is perhaps relaxation and the Y axis would be excitement. The balance between the two might not be ideal. You might want more relaxing patterns, more exciting patterns at certain times of the day, or based on the task.

This could be problematic if you're designing an office space for many different people: Sometimes they might be in a meeting, sometimes they might be working on their laptop and sometimes they might be on a zoom call. So how do you resolve that complexity?

That's not something that we explored on a larger scale. We looked at that on an individual scale. But I think generally for application, we might start to look at

patterns that most people find pleasant. It might be also that some patterns or some luminance distributions are created on a larger maybe office scale, with some level of control for each individual workstation level.

That way, the amount of light can be adjusted and maybe the spatial distribution can also be adjusted on an individual level.

I think that's why you need to have more control - that might tie to other issues to our visual sensitivity or preferences in general. But I think we would be able to find general preferences that most people agree on.

So it sounds as though lighting can make a big difference to visual comfort, visual interest, and ability to sleep. We know that brightness seems to affect mood and I guess if you've had a good night's sleep, you're more likely to feel a little bit healthier and happier, but is there anything else about the way that lighting works in an office or a workspace that will enhance mood?

I'll talk about two things there. The first one is when we are talking about variations in the spectral power distribution, perhaps to promote alertness or sleep. In some studies, it might promote alertness, but people don't like it. They don't find it pleasant, especially if maybe it tends to be towards the higher CCTs where it's the kind of cool colour temperature. So the variations in spectral power distribution could affect alertness but also could affect our mood. And then at the end of the day, it might be a matter of trade-offs.

The other aspect that could affect mood is the luminance distribution in the space. Back in the seventies, John Flynn did some amazing work looking at luminance distribution and different aspects of our mood looking at calmness, relaxation, excitement, and other aspects. So the amount of light in the space, the spectral power distribution as well as the spatial distribution in the space and how it varies over the course of the day might affect our mood.

That's something that I think we would need to start to look at, maybe using wearables or using mobile phones to prompt brief questionnaires over the course of the day. That would allow us to track small variations in mood as a function of changes in spectral power distribution, luminance, etc. It's not just a matter of lighting changes, but there's also other aspects outside of lighting or even outside of the environmental factors that could affect mood that also should be accounted for.

What would your sense be of the contribution of lighting to the key things that you need to do at work: be alert, feel motivated or concentrate for example?

I think the contribution of lighting is really important. The amount of light and the quality of the lighting could affect our ability to continue to work efficiently or impact our work productivity short term or long term in a specific space.

So along the other environmental factors lighting is really important -and one that could affect our overall satisfaction and comfort.

You mentioned that idea about being aware of time changing through the day. How important is that? Because adding tuneable lighting from warm to cool then to warm again, increases the cost and the controls and other things within a luminaire. Is that a really important thing in a lighting scheme for the workplace?

I think the variations and intensity or the spectral power distribution or spatial distribution might provide cues to occupants portraying information about what's happening outside the building. What time of the day it is, what kind of sky conditions do we have outside?

People are always eager to connect to what's happening outside their building. That's why we look at outdoor views and it's restorative aspects.

I would tend to think that variations in intensity over the course of the day, might be something that we might need to look into as opposed to fixed illuminance or fixed spectral distribution over the course of the day, which might not be only beneficial for sleep or alertness.

I think in some studies, people preferred the dynamic change, but it's again a question of what change is being looked at. So I think the ability or ability to now use electric lighting systems to create changes is amazing.

But it's really about the question of what type of change - is it changes in illuminance changes in spatial distribution? These changes might not be only important for sleep. They might also be beneficial for improving our mood and visual interest.

So there's some really fascinating work still to be done. And it sounds as though you're in a great place to continue that I really look forward to seeing your ongoing work. Thanks for sharing your expertise with us.