A PERSONALISED AND ADAPTIVE INTELLIGENT SYSTEM TO ADJUST CIRCADIAN LIGHTING FOR ELDERLY HOUSING

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Lighting Design – AAU Copenhagen

AmiEs 2016, Crete

LACK OF NATURAL DAYLIGHT AFFECTS HEALTH AND IMMUNE SYSTEM

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Current lighting systems in elderly housing

- Simple

- Made only to support visual acuity without taking into account other parameters

But elderly people have **higher demands on quality of light** as their body has to cope with immobility, pathologies and age-related functional decline

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LIGHTEL

Target group:
- **Dementia**
- **Reduced mobility**
- **Reduced vision**
- **General age conditions**

Improving the well-being of elderly through intelligent circadian lighting

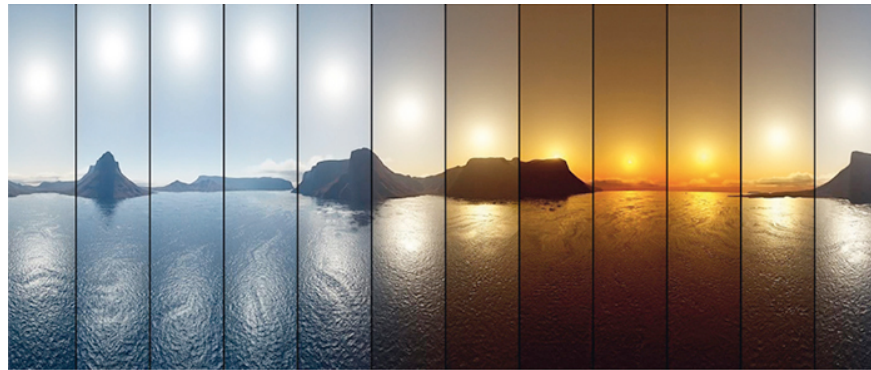AALBORG UNIVERSITY
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LighTel design based on Circadian Lighting

Circadian adjusted LED-based (CaLED) lighting is used, which can reflect the rhythm of out-door daylight.

Built-in clock regulates the timing of processes (Circadian rhythm)
Light exposure to the eyes influences Circadian rhythm
Jet lag = Circadian dysrhythmia

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Benefits of circadian lighting

- Improves sleep [1,4]
- Drives natural eating times, reduces night waking [1]
- Faster recovery times [4,5]
- Energizing during the day [6]
- Relaxation at evening/night [1,4,6]
- Promotes healthy activity [4,5]
- Increases productivity [7]
- Improves learning [7]
- Improves concentration [7]
- Improves mood & behavior [6]
- Reduces hyperactivity/ADHD [7]
- Reduces errors and accidents [7]
- Increase in memory [8]
- Faster cognitive processing speed [8]
- Reduces dementia symptoms [2,3]
- Reduces cardiovascular disease [4,5,9]
- Reduces obesity/diabetes [4,5,9]

Source: http://www.photonstarlighting.co.uk/technology/circadian_lighting/

CaLED lighting seems to positively influence age-related needs, mood, cognition, alertness, sleep and improve well-being in general

1 Figuieiro and Read, 2005; Roberts, 2008
2 Gehrmann, 2005
3 Torrington , 2006
4 (Roberts, 2000; Vetch et al., 2004; Cutolo M et al., 2005; Heschong and Roberts, 2009).
5 (Wilson, 1972; Stevens et al., 2007; Rea et al., 2008; Erren and Reiter, 2008; Arendt, 2010)
6 (Santillo et al., 2006; Musio and Santillo, 2009; Gaddy et al., Roberts 1995; Czeisler et al., 1995)
7 (Schulte 2010)
8 (Helbig 2013)
9 Fonken et al., 2010

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Circadian Lighting

We know more about the effect of lighting to animals and plants than to humans

Topology, **programming** as well as **uniformity** and the **dynamic spectral power distribution** of circadian light are still unclear and subject to theoretical debate and testing.

In addition, the focus on general public applications leaves the development for **general private use** somewhat wanting

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Data: "holistic" approach
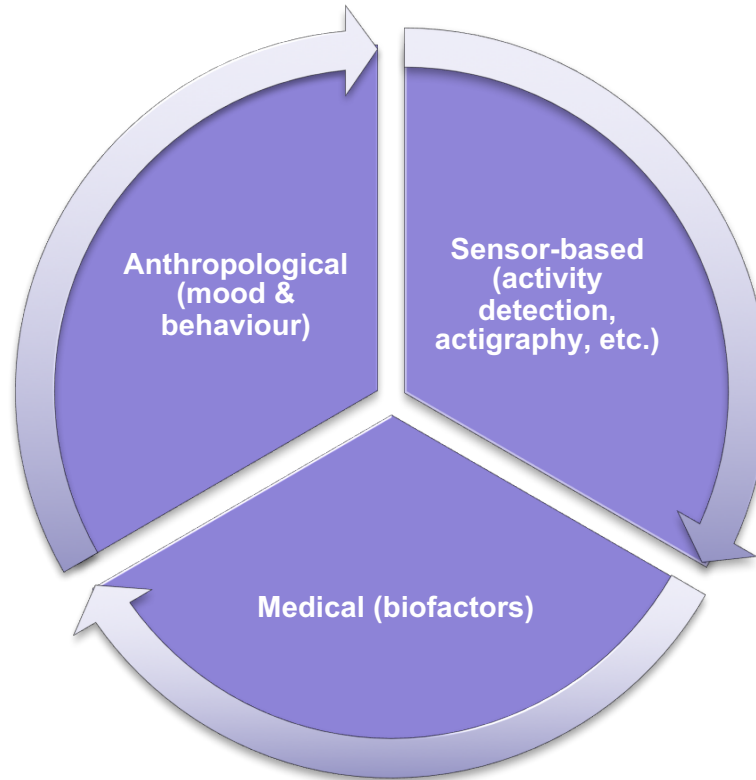
Methods

- Blood samples

- Measurement of sleep patterns

- Accelerometer (mobility)

- Inflammation tests

- Qualitative interviews (elderly and staff)

- Observations

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Anthropological factors

- **Light and safety** (perceived feeling of safety in a space)

- **Homeliness and atmosphere** (homey and cozy atmosphere for elderly)

- **Elderly and technology** (technophobia)

Sensors-based factors

- **Light sensors**: Measure daylight

- **Actigraphy**: is a wrist worn monitor containing a solid-state "Piezo-electric" accelerometer: measures activity, total sleep time (TST: the amount of time the participant spends sleeping while in bed), sleep latency (SL: time from getting to bed until falling asleep), wake after sleep onset (WASO: minutes awake during a sleep period after the initial onset of sleep, and sleep variability (SV: inter-day variability in TST).

- **ActivPal**: The activPal3™ accelerometer measures time spent sitting/lying, standing and walking, the number of steps taken, cadence and the number of sit-to-stand and stand-to-sit transitions

Medical factors

- **Pittsburgh Sleep Quality Index** (PSQI)

- **Daytime sleepiness** by the Epworth Sleepiness Scale (ESS). The ESS is an 8-item self-report measure in which participants indicate the likelihood of dozing off or falling asleep in eight different conditions.

- **Inflammatory and infectious biomarkers** (c-reactive protein (CRP), soluble urokinase plasminogen activating receptor (suPAR), white blood cell counts and inflammatory receptors, cytokines and chemokines; endocrinological parameters (cortisol, melatonin, leptin and glucose); parameters involved in diagnostics of delirium (albumin, phosphate, magnesium, sodium and potassium1)

- **Delirium** by the Confusion Assessment Method, which is a 4-criteria test for the identification of delirium in accordance with the DSM delirium criteria

- **Cognition** by the Mini Mental State Examination (MMSE) and the Montreal Cognitive Assessment (MoCA)

- **Depression** by the Major Depression Inventory (MDI); The MDI contains items that cover the ICD-10 symptoms of depression including DSM-IV major depression symptoms as well.

- **Health related quality of life** by the EuroQol (EQ-5D-3L); which is a three level version of the EQ-5D measuring health-related quality of life by assessing aspects of physical, mental and social functioning with three response levels.

- **Activities of daily living** (ADL) by the Barthel Index 20

Definition of the system

- Non-linear system:

  - Circadian lighting (topology, programming, uniformity, dynamic spectral power distribution)

  - Human factors (anthropological, sensor-based, medical)

Intelligent system

Use of Fuzzy Inference Systems (FIS)

- Fuzzy inference is the process of formulating the mapping from a given input to an output using fuzzy logic.

- The mapping then provides a basis from which **decisions can be made, or patterns discerned**.

- The strength of FIS relies on their twofold identity.
    - On the one hand, they are able to handle linguistic concepts.
    - On the other hand, they are universal approximators able to perform nonlinear mappings between inputs and outputs

- Use of the adaptive neuro-fuzzy inference system (ANFIS - based on Takagi–Sugeno fuzzy inference system).

Test plan

Test-subjects	No	Period 0	Randomization	No	Period 1 8 weeks	Period 2 8 weeks
Group A	15	Baseline	Subgroup A1	8	intervention	control
			Subgroup A2	7	control	intervention
Group B	9	Baseline	Subgroup B1	4	intervention	control
			Subgroup B2	5	control	intervention
Group C	15	Baseline	None	15	control	control

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Thank you! Great audience!
Questions? Feedback?

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